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# Water Quality Investigation Related to Seafood Processing Wastewater Discharges at Dutch Harbor, Alaska, Oct 1975-Oct 1976

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# WATER QUALITY INVESTIGATION RELATED TO SEAFOOD PROCESSING WASTEWATER DISCHARGES AT DUTCH HARBOR, ALASKA

OCTOBER 1975
OCTOBER 1976

ENVIRONMENTAL
PROTECTION
AGENCY
SURVEILLANCE AND
ANALYSIS DIVISION
SEATTLE, WASHINGTON
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16. Abstracts

Dutch Harbor, located on the Aleutian chain, has become the second largest processing center of shellfish in Alaska. Because of the large volume of wastes produced (two thirds of the total harvest weight processed) it was determined that information on the water quality effects of waste discharges and the compliance status of NPDES permits issued to seafood processors should be gathered. A brief one day study was performed in October, 1975, and a more extensive survey was conducted during October, 1976. Results indicate generally lowered water quality conditions including low dissolved oxygen concentrations near the bottom, increased nutrient concentrations within the bays, and decomposing sludge deposits of seafood wastes. An appendix discusses waste disposal practices of crab processors at Unalaska and Amaknak Islands, Alaska.

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# INTRODUCTION AND PURPOSE

One of the largest and oldest industries in Alaska is the seafood processing industry. Hundreds of millions of pounds of fish and shellfish are processed each year. The industry is widely dispersed throughout the western and southern coastal reaches of the State. Several areas, however, have significant concentrations of seafood processing facilities. The newest and most rapidly expanding of these areas is Dutch Harbor.

Dutch Harbor, located about 740 air miles southwest of Anchorage on the Aleutian chain (Figure 1), has become the second largest, only exceeded by Kodiak, processing center of shellfish in Alaska. In 1970, the five facilities located at Dutch Harbor processed approximately 20 million pounds of shellfish. By 1976, this output by eleven processors had increased more than three times (Figure 2) to about 72 million pounds. Of the total harvest weight processed, an estimated two-thirds are waste materials which are discharged following grinding into the waters of the Dutch Harbor area.

Development of an oil-staging area in the vicinity of Pacific Pearl Seafoods in Captains Bay is beginning to occur. Future buildup of activity related to oil development and exploration in this area is very likely and may have adverse water quality effects. Additionally, development of a bottom fishery is also possible within the next few years. Should this occur, wastes discharged from the processing of these fish would have an additional impact on water quality.

Because of the large volume of shellfish processed and associated wastes produced, it was determined that information on the water quality

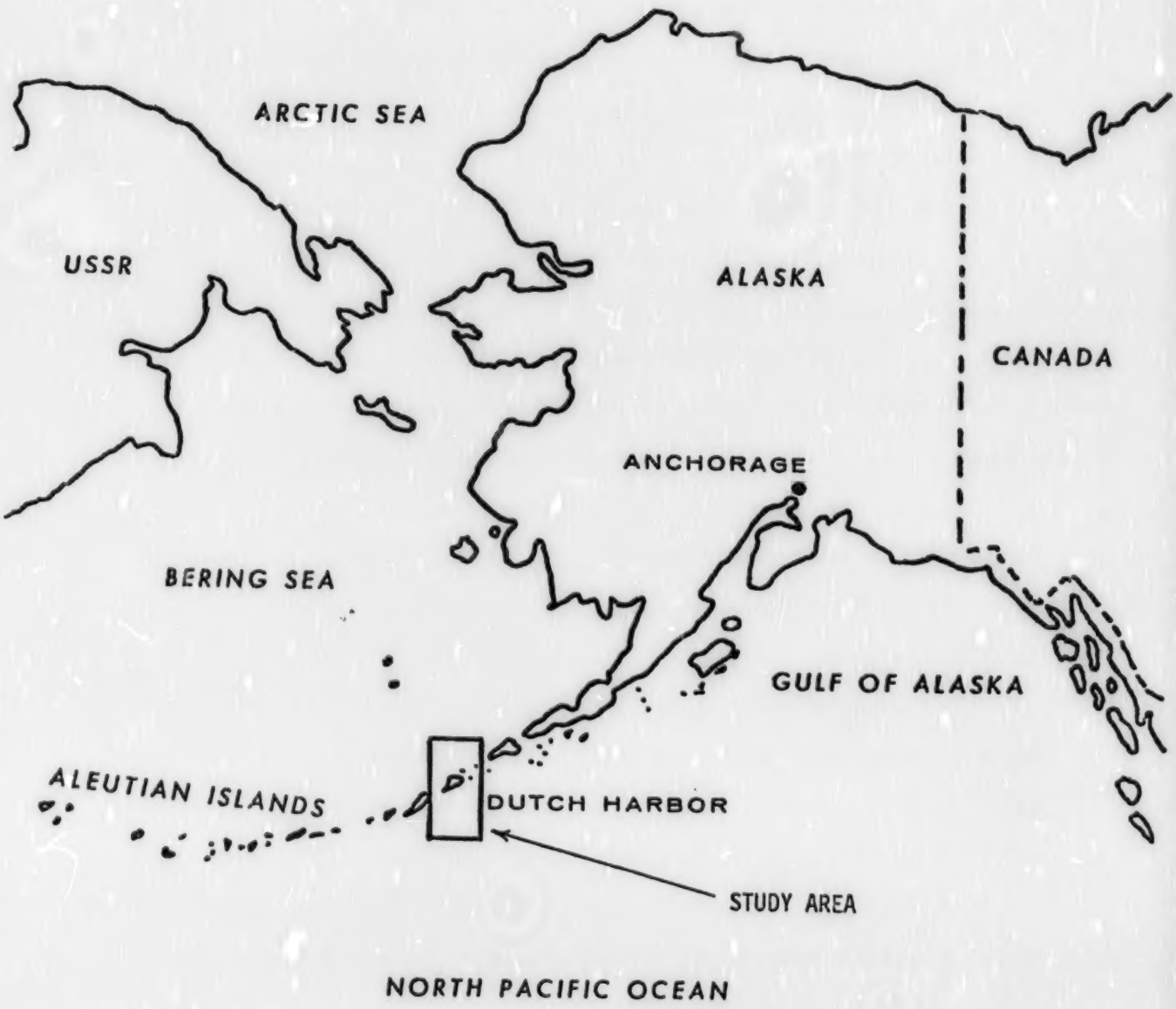
ARCTIC SEA
USSR
ALASKA
CANADA
ANCHORAGE
BERING SEA
GULF OF ALASKA
ALEUTIAN ISLANDS
DUTCH HARBOR
STUDY AREA
NORTH PACIFIC OCEAN

FIGURE 1

effects of waste discharges and the compliance status of NPDES permits issued to seafood processors should be gathered. Additionally, this data would be of importance in the future National Pollutant Discharge Elimination System (NPDES) permitting actions to municipalities, oil facilities, and new seafood processors in the area.

Due primarily to adverse weather conditions, a brief one-day survey was performed during October 1975. The data obtained were not adequate to meet total survey objectives and, therefore, a second more extensive survey effort was conducted during October 1976 for the purpose of determining:

1. The effects of waste discharges on water quality
2. The extent of seafood waste sludge deposits
3. Water current movement patterns in the Dutch Harb area
4. Compliance status of seafood processors with NPDES permit requirements.

## FINDINGS

1. Dissolved oxygen concentrations below the Alaska water quality standard of 6 mg/l were found at 5 locations during the 1975 survey and at 17 locations during the October 1976 survey.
2. Dissolved oxygen concentrations below 6 mg/l were found primarily at the 25 meter or deeper depths and usually within close proximity of the bottom. The lowest value recorded (0.0 mg/l) during the October 1976 survey, however, was found at Station 20 at the bottom at 17 meters depth.
3. Dissolved oxygen concentrations below 6 mg/l were found during both the flood and ebb tide stages on both days surveyed during October 1976.
4. Significantly increased levels of ammonia and total phosphorus concentrations observed over those at stations used as control points, were found at most stations located in Iliuliuk Harbor, Iliuliuk Bay, and Dutch Harbor.
5. Ammonia concentrations found near the bottom for all 17 stations located in Iliuliuk Harbor, Iliuliuk Bay, and Dutch Harbor ranged from <.01 mg/l to 3.8 mg/l for samples collected during the October 1976 survey. The average concentration found at these stations was 0.60 mg/l, substantially greater than the background concentrations of <0.01 mg/l found at the outer locations on the west side of Amaknak Island in Unalaska Bay and in outer Iliuliuk Bay.
6. Total phosphorus concentrations found near the bottom for all 17 stations located in Iliuliuk Harbor, Iliuliuk Bay, and Dutch Harbor ranged from 0.03 mg/l to 1.6 mg/l for samples collected during the

October 1976 survey. The average concentration found at these stations was 0.25 mg/l which is substantially greater than the background concentrations of 0.02 and 0.03 mg/l found at the control locations in Unalaska Bay and outer Iliuliuk Bay.

7. Current drogue studies conducted during the 1976 survey indicate relatively little water movement at both the near surface and the 10 to 25 meter depths within Dutch Harbor, Iliuliuk Bay, and the Iliuliuk Harbor areas.

8. Stronger surface currents were noted in Captains Bay and between the north end of Hog Island and Amaknak Island (Station 16).

9. Surface water movement was more pronounced than subsurface movements throughout the study area.

10. Water current movements as determined by the brief October 1976 current drogue studies did not fit the typical movement pattern associated with ebbing and flooding tides. Surface current movement was outward during flood tide and incoming during the ebb tide stages.

11. Bottom sediment samples obtained at most locations during both the 1975 and 1976 surveys indicate relatively high levels of organic matter. An organic sediment index of 3* was obtained at all stations except Station 2 during the 1976 survey.

12. Sludge deposits were found at the old submarine base repair dock and at locations within Iliuliuk Harbor, Iliuliuk Bay, and Dutch Harbor.

---

*"Nitrogenous, substantial nitrogen contribution, further stabilization likely."(1)

13. Accumulations of seafood waste solids in excess of 3 inches at the 30 meter radius from the end of the outfall pipe were found at the discharge locations of Easpoint Seafoods (M/V Eastpoint), Universal Seafoods (M/V Unisea), Vita Food Products (M/V Vita and M/V Viceroy), New England Fish Company (M/V Theresa Lee), and Sea Alaska Products (M/V Sea Alaska and M/V Sea Producer).

## CONCLUSIONS

1. Seafood processing waste discharges are primarily responsible for the observed depressed dissolved oxygen concentrations and increased nutrient concentrations particularly in Iliuliuk Harbor, inner Iliuliuk Bay, and in Dutch Harbor.
2. Water current movement in the vicinity of the existing outfall locations on the west side of Amaknak Island and outfall locations within Dutch Harbor do not provide for adequate dispersion of discharged waste solids.
3. Seafood wastes have been responsible for old sludge deposits found at the abandoned submarine base repair dock and at locations within Iliuliuk Harbor and the inner reach of Iliuliuk Bay south of the sill.
4. Seafood waste discharges have been and continue to be largely responsible for the formation of sludge deposits in the Dutch Harbor embayment of the study area.
5. Seafood processing wastewaters, screened or unscreened, should not be discharged to Iliuliuk Harbor including the reaches associated with the sub-base embayment and Margaret Bay.
6. Seafood processing waste solids should not be discharged to Dutch Harbor, the reach of Iliuliuk Bay inland of the sill, and Captains Bay including the reach from Amaknak Rocks to Iliuliuk Harbor.
7. Sludges found at Station 18 in 1975 (the east arm of Captains Bay) were the result of waste discharges from floating processing ships which anchored in this area in this and other years.
8. Solids should be screened from all existing process waste streams discharging to the west side of Amaknak Island. The collected solids should then be disposed of in an acceptable manner.

## PREVIOUS STUDIES

A brief water quality survey was conducted by the University of Alaska during June 1968. The principal objective of this study was to obtain information on the fate of organic matter associated with seafood processing waste (2). Ammonia concentrations were found to be normal for seawater in areas little affected by seafood processing facilities. In Iliuliuk Harbor, however, high ammonia concentrations were found. Samples taken at several depths near the southern tip of Amaknak Island in Captains Bay were characteristic of non-enriched seawater with less than .015 mg/l ammonia. At a station in the offshore waters of Unalaska Bay, the maximum ammonia concentrations diminished to less than .05 mg/l. Samples taken near the seafood processing facilities in Iliuliuk Bay at depths of 0, 5, and 10 meters, had concentrations of ammonia nitrogen of .072, .113, and .080 mg/l respectively. At a station near the most upbay reach of Iliuliuk Bay, the concentrations of ammonia nitrogen ranged from .064 to .333 mg/l between the 10 and 25 meter depths. The substantial increase in ammonia nitrogen found in the deeper waters of Iliuliuk Harbor and Bay was believed to be the result of decomposition of organic matter which had accumulated on the bottom.

The same study also showed that the dissolved oxygen concentrations were lowered in the bottom waters.

Because of the rapid buildup of processing facilities in the Dutch Harbor area and increased pollutional pressures imposed on receiving waters an October 1975 survey was performed by EPA during the peak of the seafood processing activity. All but one of the seven stations

sampled during the 1968 study, a station in Unalaska Bay offshore of Iliuliuk Bay, were sampled during the October 9, 1975 survey. A total of 11 stations were sampled during the 1975 survey.

The October 1975 survey included measurements for temperature, pH, conductivity, dissolved oxygen, ammonia nitrogen, and total phosphorus at the 1, 10, and 25 meter depths and just above the bottom. Bottom deposit samples were obtained for analysis of volatile solids, percent organic matter, and chemical oxygen demand, and for inspection of the occurrence of hydrogen sulfide odors and macroscopic marine life. Generally poor water quality, described in more detail later in this report, was found during the 1975 survey.

## DESCRIPTION OF STUDY AREA

### General

The Dutch Harbor survey area (Figure 1) is located on the north or Bering Sea side of the Aleutian Islands west of the Alaska Peninsula. The survey area consists of Captains Bay, Dutch Harbor, Iliuliuk Bay, Iliuliuk Harbor, and portions of Unalaska Bay (Figure 2). Iliuliuk Harbor is a highly contorted embayment situated between Captains and Iliuliuk Bays. Captains Bay, Iliuliuk Harbor, Iliuliuk Bay, and Dutch Harbor have limited circulation patterns largely the result of sills (Figure 5) which form physical barriers to the circulation of deep water.

### Climate

The Dutch Harbor area has a cold maritime climate with normal summer air temperatures ranging from 50 to 60 degrees Fahrenheit and normal winter temperatures ranging from 25 to 35 degrees Fahrenheit. High summer temperatures may attain 85 degrees Fahrenheit for brief periods, and low winter temperatures may reach 10 degrees Fahrenheit. Inclement weather conditions are common, and are characterized by low cloud cover which often interferes with airline transportation to the area. Winds in winter and during storms are usually strong. Wind velocities of more than 100 knots are not uncommon. During brief periods of cold winter weather, ice up to two inches thick may be found on Iliuliuk Harbor, but the other bays in the area remain ice free throughout the year.

### Oceanography

Two major freshwater streams enter the study area, the Shaishnikof River at the head of Captains Bay, and the Town River which drains Unalaska

Lake on the east side of Iliuliuk Harbor. Both streams are utilized by salmon for spawning. Several smaller streams also flow into the general survey area. The total freshwater inflow to the area slightly dilutes the salinity of the surface waters in the area.

The waters of the study area are decidedly marine rather than estuarine. Salinities ranged from 20.5 to 32.0 parts per thousand during the 1975 survey and from 19.2 to 33.9 parts per thousand during 1976. Vertical and horizontal salinity gradients which cause stratification of marine waters undoubtedly occur but their intensity, duration, and diurnal and seasonal variations were not defined as a part of these surveys.

It is evident from examination of U.S. Coast and Geodetic Survey maps that Captains Bay, Iliuliuk Harbor, and the Dutch Harbor-Iliuliuk Bay systems are three distinct basins separated by sills (pronounced underwater elevated land across the bottom of a bay or other marine watercourse; see Figure 5). One of the sills is located near the mouth of Captains Bay. Two more, one at each end of Iliuliuk Harbor, separate this basin from Iliuliuk Bay and Captains Bay. The other sill is situated near the mouth of Iliuliuk Bay and separates the Iliuliuk Bay-Dutch Harbor basin from the open waters of Unalaska Bay and the Bering Sea. These sills hinder circulation of the deep water layers within the basins. The three basins thus form traps for settleable solids and nutrients introduced into these waters.

Tides in the area are not great, having a maximum amplitude of near 10 feet. The mean tidal amplitude (mean high water to mean low water) is about four feet.

## Water Quality Standards

The present Alaska Water Quality Standards (3) designate the marine waters of the State as Classes C, D, E, and G. The standard criteria associated with marine waters that are of particular interest in this report are those for dissolved oxygen, residues in the form of settleable solids and sludge deposits, and toxic substances. Of the various classifications, the following are the most stringent criteria.

### Dissolved Oxygen

Class D - Greater than 6 mg/l in salt water.

Class E - Greater than 6 mg/l in the larvae stage. Greater than 5 mg/l in the adult stage.

### Residues, Including Oils, Floating Solids, Sludge Deposits, and Other Wastes

Class D - "Residues may not make the receiving water unfit or unsafe for the uses of this classification; nor cause a film or sheen upon, or discoloration of, the surface of the water or adjoining shoreline; nor cause a sludge or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom or upon adjoining shorelines. Residues shall be less than those levels which cause tainting of fish or other organisms and less than acute or chronic problem levels as determined by bioassay."

Class E - Same as Class D.

Settleable Solids, Suspended Solids (includes sediment and dredge spoil and fill)

Class C - No visible concentrations of sediment.

Class D - No deposition which adversely affects fish and other aquatic life reproduction and habitat.

Class E - No deposition which adversely affects growth and propagation of shellfish.

Toxic Substances

Class D - Concentrations shall be less than those levels which cause tainting of fish, less than acute or chronic problem levels as revealed by bioassay or other appropriate methods and below concentrations affecting the ecological balance.

Class E - Same as Class D.

Water Uses

Uses of the waters of the Dutch Harbor area as stipulated in the Alaska Water Quality Standards (3), consist of water contact recreation, growth and propagation of fish and other aquatic life (including waterfowl and furbearers), shellfish growth and propagation (including natural and commercial growing areas), and industrial water supply other than food processing.

Of prime importance from a water quality viewpoint is the use of these waters for holding live crab. These waters must be of sufficient quality to support these animals for periods up to two days. Live crab in the tanks of fishing vessels sometimes are held while in port for one

or more days prior to offloading during peak crabbing periods. After being offloaded from the fishing boats, the live crabs are held overboard prior to processing.

Additionally, the waters in the Dutch Harbor area constitute historic nursing and feeding grounds for young and adult crab.

Waste Sources

Processing and discharge locations for waste sources during the October 1975 survey are shown in the following table:

| Processor | Process Location | Discharge Location |
|---|---|---|
| M/V Sea Alaskan | Dutch Harbor | Dutch Harbor |
| M/V Sea Producer | Dutch Harbor | Dutch Harbor |
| M/V Theresa Lee | Dutch Harbor | Dutch Harbor |
| Pan Alaska Fisheries | Iliuliuk Harbor | Iliuliuk Harbor |
| M/V Royal Alaskan | Captains Bay | Captains Bay |
| M/V Eastpoint | Iliuliuk Harbor | Iliuliuk Harbor |
| Whitney Fidalgo | Iliuliuk Harbor | Iliuliuk Harbor |
| M/V Vita | Iliuliuk Harbor | Unalaska Bay |
| M/V Viceroy | Iliuliuk Harbor | Unalaska Bay |
| M/V Unisea | Iliuliuk Harbor | Unalaska Bay |
| Pacific Pearl Seafoods | Captains Bay | Captains Bay |

Waste sources and discharge locations as situated during the October 1976 survey are shown on Figure 2. Only Eastpoint Seafoods (M/V Eastpoint) was continuing to discharge processing wastes to Iliuliuk Harbor.

NPDES permits issued to the seafood processors in the Dutch Harbor area all contained provisions which required that all seafood wastes be reduced to a diameter of 1.27 cm (0.5 inch) or less prior to discharge. The discharge of this waste was to be at least 13 meters (7 fathoms) below mean lower low water. Monitoring of bottom conditions is required by use of bottom cores to determine the amount of solids accumulation around the outfall. If more than 3 inches of waste solids is found, one year from that time the permittee is required to install a screening device equivalent to a tangential screen with a grid spacing of 1 mm (0.040 inch) or less. Seafood processing wastes which are retained on this screening system must be disposed of by 1) recovery, 2) other means approved by the Regional Administrator, or 3) transport (without loss of solids) to a specified deep water disposal site.

Other than seafood processing wastes, there are currently no other existing significant industrial discharges in the Dutch Harbor area. Future development of the area, however, as related to oil development and exploration activities and the development of a bottom fishery is very likely and may have significant environmental impact.

Other existing discharges are primarily treated domestic wastes from approximately 1000 employees associated with the seafood processing facilities, and from the villages of Dutch Harbor and Unalaska. These villages have a combined population near 350 people, and are partially sewered, but do not provide for treatment of domestic wastes. Except for bacteriological effects, domestic discharges are insignificant relative to the effect of seafood wastewater discharges.

## SURVEY METHODS

### Water Quality

During the October 1975 survey, samples were collected by EPA personnel typically at four depths during one flood and one ebb tide stage at 11 stations. Sampling started within two and one-half hours of the onset of each of the two tide stages, and was completed at all 11 stations before the termination of each tidal stage.

During the October 1976 survey samples for chemical and physical analysis were collected jointly by the Alaska Department of Environmental Conservation (ADEC) and Environmental Protection Agency personnel from 32 stations (Figures 3 and 4).

Dissolved oxygen, temperature, conductivity, and pH were determined with a Hydrolab Model 6D Surveyor Portable Water Monitor* for all stations sampled by EPA. A Martek Water Quality Analyzer* was utilized by the ADEC personnel during the 1976 survey. The dissolved oxygen probes of these instruments were calibrated daily in salt water by the standard Winkler method prior to each sampling run and each time a suspected erratic value for this parameter was obtained.

Salinity determinations were measured directly with the Martek instrument and were calculated from the conductivity and temperature data obtained with the Hydrolab instrument.

### Bottom Sediments

Bottom deposit samples were obtained at 11 stations by use of a small

*Use of product and company names is for identification only and does not constitute endorsement by the U.S. Environmental Protection Agency.

dredge during the 1975 study and at 7 stations during the 1976 survey to determine the organic content and decomposition characteristics of the deposits; the presence of hydrogen sulfide by smell; and to obtain general information pertaining to the occurrence of macroscopic (readily visible) animals or plants associated with the bottom reaches of the study area.

Chemical analyses of the bottom deposit samples were performed at the EPA, Region X laboratory. Samples for analysis were packed in ice after collection and shipped in ice filled chests.

Diving Observations

During the October 1976 survey scuba-diving teams using "dry suit" SCUBA gear and composed of EPA Region X and NEIC-Denver personnel, inspected the outfall locations of seafood processing wastewater discharges, checked for line ruptures and determined the extent of seafood waste solids accumulations around the outfalls. EPA divers utilized measuring tapes and rods, calibrated lines, maps, and cameras to define and record waste discharge accumulations. Diving activities are detailed in Appendix A.

Current Drogue Studies

Water currents in the Dutch Harbor vicinity during the October 1976 survey were measured by use of drogues fabricated from 12 to 18 inch diameter plastic buoys, wooden warehouse pallets, nylon line, and small gunny sacks. The Alaska Department of Fish and Game courteously provided the gunny sacks as well as binoculars and spotting scopes to track the course of drogues. Fifteen to twenty pounds of rocks were placed in the sacks and one of these was tied to each pallet to assure that the pallets would be suspended at the selected depths.

Drogue movement after the first day of observations was measured with the aid of radar on board a small fishing boat. A minimum of three bearings was taken to fix drogue locations during the tracking process. The courses of the drogues were plotted on Coast and Geodetic Survey maps.

Tidal data from "Tide Tables 1976 High and Low Water Predictions, West Coast of North and South America" (4) were used to determine the onset and duration of each tidal cycle and to determine periods of water sampling.

Compliance Monitoring

In-plant inspections were performed to determine compliance with NPDES permit conditions. During the 1976 survey, inspections were performed by both EPA and ADEC personnel. Samples of the effluent stream were obtained from most of the facilities for analysis of ammonia, total phosphorus, COD, total volatile solids, and total organic carbon (Table 6).

Sample Shipment

Samples were shipped in ice-packed containers, according to established chain-of-custody procedures, to the U.S. Environmental Protection Agency National Enforcement Investigations Center Laboratory at Denver, Colorado.

Bottom sediment samples were shipped to the Region X, EPA Laboratory in Seattle, Washington.

## DISCUSSION OF RESULTS

### General

Generally lowered water quality conditions were found in the Dutch Harbor study area during both the 1975 and 1976 surveys. Low dissolved oxygen concentrations near the bottom, increased nutrient concentrations within the bays, and decomposing sludge deposits of seafood wastes were encountered during both the 1975 and 1976 surveys.

### Temperature and Salinity

Temperature and salinity data (Tables 2, 3, and 3A) were gathered during both surveys to calculate density values, and to correct for dissolved oxygen values for saline waters. Calculations for density were based on values recorded in the Handbook of Oceanographic Tables (5). During the 1976 survey, salinity values ranged from 19.2 parts per thousand at the one meter depth in Iliuliuk Harbor to 33.9 parts per thousand at the near-bottom depths. Non-saline waters, primarily from the Unalaska and Shaishnikof Rivers measurably diluted the surface marine waters in the study area. The seaward reaches of both Captains Bay and Iliuliuk Bay were weakly stratified. Iliuliuk Bay was strongly stratified with a distinct layer of relatively warm, less dense lens of less saline surface and near-surface water overlaying deeper, cooler more saline and more dense waters.

### Dissolved Oxygen

Dissolved oxygen concentrations at the 25 meter depth determined for selected stations during a June 1968 study (Table 1) conducted by the

University of Alaska (2), were below the Alaska Water Quality Standards of 6 mg/l (3) in the northeastern portion of Captains Bay and at 3 locations in Iliuliuk Bay on the south side of a sill separating Iliuliuk Bay from the waters of Unalaska Bay.

Low dissolved oxygen concentrations were again found in the deeper waters of these areas during the October 9, 1975 water quality monitoring investigation (Table 2).

During the 1976 survey, dissolved oxygen data (Table 3 and 3A) were collected during ebb and flood tide stages on October 19 and October 24. Dissolved oxygen values below the Alaska Water Quality Standard of 6 mg/l were recorded within one or more meters of the bottom at Stations 1, 3, 4, 7, 20, 23-29, and 32-36, located (Figure 3) as follows:

| Station | General Location |
|---|---|
| 1,3,4,7 | Captains Bay |
| 20 | Old Submarine Repair Dock |
| 23-29 | Iliuliuk Bay |
| 32-36 | Dutch Harbor |

For the Captains Bay stations it is believed that the low dissolved oxygen values are primarily representative of natural conditions encountered in a relatively deep fjord-type water body. However, for the other stations located in Iliuliuk Harbor (submarine dock), Iliuliuk Bay, and Dutch Harbor, the depressed bottom dissolved oxygen concentrations are primarily the result of the decomposition of organic matter in seafood processing wastes. While Iliuliuk Bay does not receive any direct

discharge of processing wastes, wastes discharged within Dutch Harbor and at the entrance to Iliuliuk Bay from Iliuliuk Harbor by Eastpoint Seafoods and in the past by other processors within Iliuliuk Harbor, probably are transported to the deeper portions of Iliuliuk Bay.

Station 20 located in quiescent waters on the south side of Expedition Island in the vicinity of the old submarine base repair dry dock (Figure 4) yielded the lowest recorded dissolved oxygen value of 0.0 mg/l during the 1976 study. Diving observations in this area confirmed the existence of extensive black decomposing sludge deposits. During the previous season (1975-1976) crab processing wastes had been discharged in this area which undoubtedly contributed to the formation of this sludge layer and associated depressed dissolved oxygen levels.

Stations 23 through 29, located in the Iliuliuk Bay area, also showed depressed dissolved oxygen concentrations. These are located in the deeper portion of the bay (17 to 20 fathoms) and are on the Unalaska side (south) of a sill (7 to 8 fathoms) which restricts water movement in and out of Iliuliuk Bay and thus encourages the buildup of organic sediments from wastes discharged by the City of Unalaska, the processors within Iliuliuk Harbor (some domestic wastes), the M/V Eastpoint, and dischargers located in Dutch Harbor. Depressed oxygen levels were also observed in this area during the 1975 survey.

Stations 32 through 36 are located within Dutch Harbor. Three processing facilities, the M/V Sea Alaska, M/V Sea Producer, and M/V Theresa Lee discharge process wastewaters into Dutch Harbor. Dissolved oxygen concentrations recorded at these stations during both 1975 and 1976 were also below the state standard of 6 mg/l.

Nutrients

Ammonia and total phosphorus concentrations obtained during the 1976 study for various depths during flood and ebb tide stages for water quality stations are presented in Tables 3 and 3A. Relatively low nutrient concentrations were found in Captains Bay (1, 2, 4, and 7) and at stations used as control points (9, 16, and 17). Additionally, low concentrations were found at Stations 30 and 31, located on the seaward side of the sill in Iliuliuk Bay. Stations 18 and 19, located in a transitional zone between Captains Bay and Iliuliuk Harbor, showed a slight tendency towards increased nutrient concentrations. Stations 8 and 14, located in the vicinity of the outfalls on the west side of Amaknak Island, also showed slightly increased concentrations. Significantly higher levels of nutrient concentrations were found at Stations 22 through 29 (Iliuliuk Bay) and Stations 32 through 36 (Dutch Harbor).

High levels of ammonia and total phosphorus were found to be localized in nature and attributable to the nutrients (both the solid and liquid portion of their waste streams) discharged to these waters from crab processing plants (Table 6), localized sludge deposits of new and old crab wastes, and domestic wastes discharged to the water from both the processing vessels and the City of Unalaska. There does not appear to be any indication that the observed high concentrations of nutrients in the fall are due to up-welling of nutrient-rich water from the deep offshore reaches of the Bering Sea. The control stations in marine waters are low in nutrients as are the freshwater streams (Table 6) which enter the study area.

Bottom Sediments

Analytical results of bottom sediment sample analyses are presented in Tables 4 and 5.

Samples obtained during 1975 and 1976 from Station 2 (Captains Bay) in the vicinity of the Pacific Pearl processing plant do not indicate recent organic waste deposits. Clean sand and gravel was found during 1975 and only 3.3 percent organic matter from the sample obtained in 1976 reflecting a Type I organic sediment classification (5) of "inorganic or aged, stabilized organic deposits". Relatively small amounts of crab processing wastes have been discharged to Captains Bay in this vicinity.

During the 1974-1975 season, the M/V Royal Alaskan was moored between Stations 1 and 18 and discharged processing wastes at this location. A sediment sample from Station 18 shows evidence of organic deposits. Chemical analysis of the sample yielded an 11.6 percent volatile solids content, 21.8 percent organic matter, and a chemical oxygen demand (COD) of 255 grams per kilogram (g/kg).

Results of additional sediment samples obtained during the 1975 survey indicate the same general locations of sludge deposits and organic sediments determined during the 1976 survey. Decomposing sludge with pieces of crab shells were found near the Royal Alaskan outfall which was discharging to Iliuliuk Harbor at that time. Evidence of past processing discharges to Iliuliuk Harbor is shown in the chemical analyses of bottom samples collected at Stations 21A, 21B, and 22A during the 1975 survey and at Station 20 during the 1976 survey. Sludge deposits were also found at stations located within Dutch Harbor.

Analytical results of the 1976 bottom sediment samples (Table 5) obtained at Stations 1, 2, 4, 20, 21, 24, and 34 as well as results from the 1975 survey correlate well with the lowered dissolved oxygen observations and locations of known waste discharge areas. Stations within Captains Bay (1, 2, and 4) show relatively low levels of organic matter in the sediments. Station 20, located in quiet waters where sludge beds were observed and where processing wastes were discharged in previous years, showed the highest levels of organic content, particularly percent organic matter. Stations 24 and 34 also had relatively high levels of COD, ammonia, volatile solids, and percent organic matter. It should be noted that, except for Station 2, a Type III classification--"Nitrogenous, substantial nitrogen contribution, further stabilization likely" was found at all other sediment stations.

Diving observations made in Dutch Harbor (Appendix A) confirmed the accumulation of seafood waste sludge deposits around the outfalls. Sediment samples obtained from the Dutch Harbor stations (Table 5) indicate high organic content. Samples consisted of soft, foul-smelling sludge and supported primarily pollution-tolerant polychaete worms. Water current movement in Dutch Harbor is negligible as indicated by diving observations and current drogue observations shown on Figures 6 and 7. Waste solids discharged to this waterbody do not readily disperse. Decomposition of the accumulated wastes causes water quality degradation.

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3. State of Alaska, Department of Environmental Conservation, "Water Quality Standards", as revised October 1973.

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TABLE 1

Dissolved Oxygen Concentrations in Milligrams Per Liter
at Selected Sites and Depths in the Dutch Harbor Area (3)
June 1968

| | Station Numbers | | | | | |
|---|---|---|---|---|---|---|
| Depth | 1 | 21 | 24 | 27 | 28 | 30 |
| 0 | 7.9 | 6.8 | 8.0 | 8.1 | 7.9 | 7.9 |
| 5 | 8.0 | 7.2 | 8.0 | 8.1 | 8.3 | 8.0 |
| 10 | 7.7 | 7.4 | 7.8 | 8.1 | 7.5 | 7.6 |
| 15 | 6.9 | | 7.3 | 7.8 | 7.4 | 7.3 |
| 20 | 7.1 | | | | | |
| 25 | | | 4.3 | 4.8 | 5.5 | |
| 30 | 6.8 | | | | | |
| 40 | 5.6 | | | | | |

TABLE 2

ANALYTICAL RESULTS
WATER QUALITY SAMPLING STATIONS
DUTCH HARBOR, ALASKA
OCTOBER 9, 1975

| Station | Time | Depth[1/] (meters) | °C Temp | Salinity (°/oo) | Density (σt) | Dissolved Oxygen mg/l | Ammonia Nitrogen mg/l | Total Phosphorus mg/l |
|---|---|---|---|---|---|---|---|---|
| 2 | 0950 | 1 | 6.9 | 30.0 | 24.53 | 8.3 | .03 | .046 |
| | 0952 | 10 | 6.4 | 31.5 | 24.77 | 7.8 | .04 | .067 |
| | 0953 | 25 | 6.2 | 32.0 | 25.19 | 7.7 | .06 | .058 |
| | 0956 | (48) | 4.0 | 31.0 | 24.63 | 4.7 | -- | -- |
| | 1615 | 1 | 7.5 | 31.0 | 24.24 | 7.8 | .04 | .055 |
| | 1617 | 10 | 7.2 | 32.0 | 25.06 | 7.5 | .05 | .057 |
| | 1618 | 25 | 6.5 | 32.0 | 25.14 | 7.7 | .04 | .056 |
| | 1620 | (40) | 5.4 | 32.0 | 25.18 | (6.3) | -- | -- |
| 1 | 1014 | 1 | 6.9 | 30.5 | 23.92 | 8.4 | .03 | .055 |
| | 1015 | 10 | 6.4 | 31.5 | 24.77 | 8.0 | .05 | .059 |
| | 1016 | 25 | 6.0 | 31.5 | 24.81 | 7.5 | .02 | .063 |
| | 1017 | (42) | 5.6 | 31.5 | 24.86 | 7.0 | -- | -- |
| | 1632 | 1 | 7.2 | 31.0 | 24.27 | 7.8 | .02 | .052 |
| | 1633 | 10 | 6.6 | 32.0 | 25.13 | 7.4 | .05 | .060 |
| | 1634 | 25 | 6.3 | 32.0 | 25.19 | 7.5 | .05 | .060 |
| | 1637 | (50) | 4.6 | 32.0 | 25.37 | 5.7 @ 42 | -- | -- |
| 19 | 1031 | 1 | 7.4 | 25.5 | 19.94 | 8.7 | .07 | .052 |
| | 1032 | (10) | 6.2 | 31.5 | 24.79 | 7.4 | .08 | .065 |
| | 1647 | 1 | 8.0 | 24.0 | 18.70 | 9.2 | .06 | .055 |
| | 1648 | 10 | 6.4 | 32.0 | 25.17 | 7.4 | .06 | .059 |
| | 1649 | (12) | 6.3 | 32.0 | 25.18 | -- | -- | -- |
| 21 | 1054 | 1 | 7.4 | 20.5 | 16.03 | 8.4 | .08 | .052 |
| | 1055 | 10 | 7.0 | 31.0 | 24.30 | 7.4 | .09 | 081 |
| | 1056 | (12) | 6.4 | 31.0 | 24.38 | 7.0 | -- | -- |
| | 1655 | 1 | 8.1 | 20.5 | 15.95 | 8.5 | .04 | .060 |
| | 1656 | 10 | 6.5 | 31.0 | 24.36 | 7.5 | .08 | .064 |
| | 1657 | (16) | 6.3 | 31.5 | 24.78 | 6.8 | -- | -- |

TABLE 2 (cont.)

| Station | Time | Depth[1/] (meters) | °C Temp | Salinity (°/oo) | Density (σt) | Dissolved Oxygen mg/l | Ammonia Nitrogen mg/l | Total Phosphorus mg/l |
|---|---|---|---|---|---|---|---|---|
| 22 | 1104 | 1 | 6.9 | 28.0 | 21.97 | 8.3 | .04 | .068 |
| | 1105 | 10 | 6.4 | 31.0 | 24.38 | 7.1 | .15 | .078 |
| | 1106 | (15) | 6.3 | 31.5 | 24.81 | 7.1 | -- | -- |
| | 1709 | 1 | 7.2 | 28.0 | 21.93 | 9.6 | .18 | .073 |
| | 1710 | 10 | 6.5 | 32.0 | 25.16 | 7.6 | .14 | .076 |
| | 1711 | (15) | 6.3 | 32.0 | 25.18 | 7.3 | -- | -- |
| 24 | 1110 | 1 | 6.9 | 30.5 | 23.92 | 7.9 | .08 | .094 |
| | 1111 | 10 | 6.3 | 31.5 | 24.78 | 7.7 | -- | -- |
| | 1112 | 25 | 6.2 | 31.5 | 24.89 | 7.5 | .18 | .082 |
| | 1115 | (35) | 6.0 | 27.0 | 21.28 | 7.0 | -- | -- |
| | 1715 | 1 | 6.9 | 30.5 | 23.92 | 8.6 | .06 | .062 |
| | 1716 | 10 | 6.3 | 32.0 | 25.18 | 7.9 | .12 | .070 |
| | 1718 | 25 | 6.1 | 32.0 | 25.20 | 7.3 | .20 | .086 |
| | 1720 | (29) | 6.0 | 32.0 | 25.21 | 6.5 | -- | -- |
| 27 | 1133 | 1 | 6.8 | 30.5 | 23.93 | 8.0 | .10 | .068 |
| | 1134 | 10 | 6.5 | 31.5 | 24.75 | 7.6 | .12 | .082 |
| | 1135 | 25 | 6.3 | 31.5 | 24.78 | 6.8 | .10 | .069 |
| | 1137 | (38) | 5.6 | 31.5 | 24.86 | 1.5 | -- | -- |
| | 1734 | 1 | 6.9 | 30.5 | 23.91 | 8.5 | .09 | .086 |
| | 1735 | 10 | 6.3 | 31.0 | 24.39 | 8.4 | .08 | .063 |
| | 1737 | 25 | 6.2 | 31.0 | 24.40 | 8.4 | .10 | .067 |
| | 1738 | (32) | 5.8 | 31.0 | 24.45 | 5.7 | -- | -- |
| 35 | 1300 | 1 | 7.3 | 30.0 | 24.25 | 9.3 | .05 | .065 |
| | 1302 | 10 | 6.5 | 31.5 | 24.75 | 7.4 | .17 | .083 |
| | 1303 | 25 | 6.2 | 32.0 | 25.19 | 6.6 | .31 | .107 |
| | 1305 | (29) | 6.1 | 32.0 | 25.20 | 5.4 | -- | -- |
| | 1816 | 1 | 7.0 | 30.0 | 23.51 | 10.5 | .020 | .060 |
| | 1817 | 10 | 6.4 | 31.0 | 24.38 | 9.4 | .160 | .084 |
| | 1818 | (25) | 6.1 | 31.0 | 24.41 | 7.9 | .150 | .072 |

TABLE 2 (cont.)

| Station | Time | Depth[1/] (meters) | °C Temp | Salinity (°/oo) | Density (σt) | Dissolved Oxygen mg/l | Ammonia Nitrogen mg/l | Total Phosphorus mg/l |
|---|---|---|---|---|---|---|---|---|
| 37 | 1331 | 1 | 7.1 | 30.5 | 23.89 | 9.3 | .06 | .069 |
| | 1333 | 10 | 6.2 | 32.0 | 25.19 | 6.5 | .21 | .091 |
| | 1335 | 25 | 6.0 | 34.0 | 26.79 | 5.8 | .20 | .084 |
| | 1336 | (27) | 5.8 | 31.0 | -- | 4.2 | -- | -- |
| | 1830 | 1 | 7.4 | 30.0 | 23.46 | 10.4 | .05 | .078 |
| | 1831 | 10 | 6.2 | 32.0 | 25.19 | 6.9 | .22 | .094 |
| | 1833 | (25) | 6.0 | 32.0 | 25.21 | 6.3 (3.7)* | .06 | .051 |
| 28 | 1147 | 1 | 6.8 | 30.0 | 23.54 | 8.4 | .08 | .067 |
| | 1149 | 10 | 6.3 | 31.0 | 24.39 | 7.8 | .10 | .069 |
| | 1150 | 25 | 6.2 | 31.5 | 24.79 | 8.4 | .04 | .055 |
| | 1153 | (35) | 6.0 | 27.0 | -- | 8.7 | -- | -- |
| | 1746 | 1 | 6.6 | 31.0 | 24.38 | 8.4 | .10 | .067 |
| | 1747 | 10 | 6.3 | 31.0 | 24.39 | 8.6 | .04 | .058 |
| | 1748 | 25 | 6.1 | 32.0 | 25.20 | 8.7 | .04 | .054 |
| | 1749 | (35) | 6.0 | 32.0 | 25.21 | 7.3 | -- | -- |
| 30 | 1235 | 1 | 7.0 | 30.5 | 23.90 | 8.0 | .09 | .064 |
| | 1236 | 10 | 6.8 | 31.5 | 24.72 | 8.3 | .03 | .268 |
| | 1237 | (15) | 6.3 | 31.5 | 24.78 | 8.6 | .03 | .026 |
| | 1801 | 1 | 6.8 | 31.0 | 24.33 | 9.1 | .06 | .057 |
| | 1802 | 10 | 6.3 | 32.0 | 25.18 | 9.1 | .04 | .052 |
| | 1804 | (12) | 6.2 | 32.0 | 25.19 | 9.0 | -- | -- |

NOTE: Morning times were on ebbing tide. Afternoon times were on flooding tide.

*This value obtained about 200 feet from Station #9 in deeper water.

1/Depth to bottom may differ from the morning run to afternoon run because exact station location was not determined by use of radar.

TABLE 3

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 19, 1976

| | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | Time | 1/ Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l |
| 1 | 1325 | 1 | 6.1 | 23.6 | 18.67 | 12.2 | <.01 | .07 | 1720 | 1 | 6.2 | 20.5 | 16.25 | 12.4 | <.01 | .02 |
| | | 10 | 6.2 | 32.8 | 25.82 | 10.4 | <.01 | .02 | | 10 | 6.2 | 32.8 | 25.82 | 10.4 | <.01 | .08 |
| | | 25 | 6.1 | 33.2 | 26.14 | 9.5 | <.01 | .03 | | 25 | 6.1 | 33.3 | 26.22 | 8.5 | <.01 | .04 |
| | | 50* | 4.3 | 33.9 | 26.90 | 4.6 | <.01 | .08 | | 46* | 4.6 | 33.8 | 26.79 | 5.4 | <.01 | .07 |
| 2 | 1251 | 1 | 6.1 | 22.2 | 17.51 | 12.2 | <.01 | .02 | 1700 | 1 | 6.1 | 14.0 | 11.03 | 13.0 | .04 | .03 |
| | | 10 | 6.2 | 32.7 | 25.74 | 10.4 | <.01 | .02 | | 10 | 6.2 | 32.7 | 25.74 | 10.3 | <.01 | .03 |
| | | 25 | 6.1 | 33.2 | 26.15 | 8.5 | <.01 | .04 | | 25 | 6.2 | 33.2 | 26.13 | 8.6 | .01 | .06 |
| | | 43* | 5.4 | 33.3 | 26.31 | 7.0 | <.01 | .06 | | 30 | 6.0 | 33.3 | 26.23 | 8.3 | .02 | .08 |
| 3 | 1309 | 1 | 6.1 | 25.8 | 20.34 | 12.3 | — | — | — | — | — | — | — | — | — | — |
| | | 10 | 6.2 | 32.8 | 25.82 | 10.5 | — | — | | — | — | — | — | — | — | — |
| | | 25 | 6.1 | 33.2 | 26.14 | 9.7 | — | — | | — | — | — | — | — | — | — |
| | | 50 | 4.2 | 33.5 | 26.60 | 4.5 | — | — | | — | — | — | — | — | — | — |
| | | 62* | 3.5 | 33.4 | 26.60 | 3.3 | — | — | | — | — | — | — | — | — | — |
| 4 | 1233 | 1 | 6.0 | 21.0 | 16.56 | 12.5 | <.01 | .01 | 1640 | 1 | 6.1 | 21.0 | 16.57 | 12.1 | <.01 | .01 |
| | | 10 | 6.2 | 32.7 | 25.74 | 10.6 | <.01 | .02 | | 10 | 6.2 | 32.9 | 25.90 | 9.9 | <.01 | .03 |
| | | 25 | 6.0 | 33.2 | 26.15 | 9.2 | <.01 | .03 | | 25 | 6.0 | 33.3 | 26.23 | 9.0 | <.01 | .04 |
| | | 50 | 4.6 | 33.5 | 26.65 | 5.1 | — | — | | 50 | — | — | — | — | — | — |
| | | 60 | — | — | — | — | <.01 | .10 | | 60 | 3.8 | 33.6 | 26.48 | 3.9 | <.01 | .09 |
| | | 75 | 3.4 | 33.5 | 26.68 | 3.2 | — | — | | 75 | 3.4 | 33.7 | 26.84 | 3.2 | — | — |
| | | 80* | 3.1 | 33.3 | 26.55 | 3.1 | — | — | | 80* | 3.4 | 33.4 | 26.60 | 3.0 | — | — |
| 7 | 1208 | 1 | 6.1 | 26.6 | 20.97 | 12.7 | <.01 | .01 | 1620 | 1 | 6.2 | 20.5 | 16.15 | 12.6 | <.01 | .01 |
| | | 10 | 6.2 | 32.6 | 25.67 | 10.9 | <.01 | .03 | | 10 | 6.2 | 32.9 | 26.90 | 10.4 | <.01 | .03 |
| | | 25 | 6.0 | 33.1 | 26.39 | 9.6 | <.01 | .03 | | 25 | 6.0 | 33.3 | 26.23 | 8.8 | <.01 | .04 |
| | | 52 | 3.8 | 33.6 | 26.52 | 4.0 | <.01 | .09 | | 60 | 3.6 | 33.6 | 26.74 | 3.7 | <.01 | .09 |
| | | 75 | 3.5 | 33.3 | 26.52 | 3.6 | — | — | | 75 | 3.5 | 33.5 | 26.68 | 3.4 | — | — |
| | | 100 | 3.2 | 33.3 | 26.54 | 2.8 | — | — | | 100 | 3.3 | 33.5 | 26.69 | 2.9 | — | — |
| | | 107 | 3.2 | 33.3 | 26.54 | 2.5 | — | — | | 108 | 3.2 | 33.4 | 26.62 | 2.6 | — | — |

1/ Meters

* Depth to bottom

TABLE 3 (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 19, 1976

| | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/1 | $NH_3$ mg/1 | TP mg/1 | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/1 | $NH_3$ mg/1 | TP mg/1 |
| 8 | 1150 | 1 | 6.2 | 21.5 | 16.94 | 12.5 | <.01 | .03 | 1605 | 1 | 6.2 | 25.2 | 19.84 | 12.0 | <.01 | .01 |
| | | 10 | 6.2 | 32.8 | 25.72 | 10.7 | .03 | .07 | | 10 | 6.2 | 33.0 | 25.98 | 10.6 | <.01 | .05 |
| | | 25 | 5.8 | 33.3 | 26.27 | 9.4 | <.01 | .17 | | 28* | 5.8 | 33.6 | 26.50 | 9.0 | <.01 | .15 |
| 9 | 1125 | 1 | 6.0 | 23.5 | 18.53 | 12.4 | <.01 | .06 | 1540 | 1 | 6.0 | 23.8 | 17.77 | 12.3 | <.01 | .04 |
| | | 10 | 6.1 | 32.9 | 25.91 | 10.7 | <.01 | .03 | | 10 | 6.2 | 33.2 | 26.13 | 10.5 | <.01 | .07 |
| | | 25 | 6.0 | 33.2 | 26.18 | 9.9 | <.01 | .03 | | 25 | 5.8 | 33.5 | 26.42 | 9.5 | <.01 | .43 |
| | | 44 | 5.7 | 33.4 | 26.36 | 9.2 | <.01 | .07 | | 80* | 5.7 | 33.7 | 26.59 | 8.5 | <.01 | .03 |
| 11 | 1105 | 1 | 6.1 | 28.2 | 22.21 | 12.0 | — | — | Sta. | 1 | 6.2 | 24.6 | 19.37 | 12.5 | — | — |
| | | 10 | 6.1 | 32.8 | 25.83 | 10.1 | — | — | 12 | 10 | 6.2 | 33.0 | 25.98 | 10.8 | — | — |
| | | 25 | 6.1 | 33.1 | 26.07 | 10.0 | — | — | @ | 25 | 5.8 | 33.5 | 26.42 | 9.5 | — | — |
| | | 50* | 5.7 | 33.4 | 26.73 | 8.8 | — | — | 1520 | 48* | 5.7 | 33.6 | 26.51 | 8.9 | — | — |
| 13 | 1055 | 1 | 5.9 | 25.6 | 20.18 | 11.9 | — | — | 1515 | 1 | 6.2 | 20.5 | 16.15 | 12.8 | — | — |
| | | 10 | 6.2 | 32.7 | 25.74 | 10.8 | — | — | | 10 | 6.2 | 33.1 | 26.06 | 10.7 | — | — |
| | | 16* | 6.2 | 32.9 | 25.90 | 10.5 | — | — | | 22* | 5.8 | 33.5 | 26.42 | 9.3 | — | — |
| 14 | 1030 | 1 | 6.0 | 25.8 | 20.34 | 11.4 | .02 | .03 | 1502 | 1 | 6.4 | 20.1 | 15.82 | 12.5 | <.01 | .03 |
| | | 10 | 6.2 | 32.6 | 25.66 | 10.7 | <.01 | .03 | | 10 | 6.2 | 33.2 | 26.15 | 10.1 | .02 | .07 |
| | | 14* | 6.2 | 32.8 | 25.82 | 10.2 | .12 | .05 | | 14* | 6.2 | 33.2 | 26.15 | 9.8 | .04 | .04 |
| 16 | 1010 | 1 | 6.1 | 31.5 | 24.89 | 11.6 | <.01 | .03 | 1450 | 1 | 6.3 | 30.3 | 23.84 | 12.0 | <.01 | .04 |
| | | 10 | 6.1 | 33.1 | 26.05 | 10.7 | .03 | .03 | | 10 | 6.2 | 33.0 | 25.98 | 10.9 | <.01 | .02 |
| | | 15* | 6.1 | 33.5 | 26.39 | 10.2 | <.01 | .03 | | 15* | 6.1 | 33.2 | 26.14 | 10.4 | <.01 | .03 |
| 17 | 1245 | 1 | 5.8 | 32.8 | 25.87 | 10.5 | <.01 | .03 | 1725 | 1 | 5.9 | 32.0 | 25.23 | 10.4 | <.01 | .02 |
| | | 10 | 5.8 | 32.8 | 25.87 | 10.6 | <.01 | .02 | | 10 | 5.8 | 32.8 | 25.87 | 10.3 | <.01 | .02 |
| | | 25 | 5.7 | 32.8 | 25.88 | 10.7 | <.01 | .02 | | 25 | 5.7 | 32.8 | 25.88 | 10.1 | <.01 | .03 |
| | | 42* | 5.5 | 32.8 | 25.90 | 9.0 | <.01 | .02 | | 42* | 5.6 | 32.8 | 25.89 | 9.1 | <.01 | .02 |

TABLE 3 (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 19, 1976

| | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l |
| 18 | 0930 | 1 | 5.7 | 27.6 | 21.75 | 11.4 | <.01 | .02 | 1535 | 1 | 6.0 | 25.4 | 20.02 | 11.7 | <.01 | .02 |
| | | 10 | 5.9 | 32.5 | 25.62 | 10.4 | <.01 | .03 | | 10 | 5.9 | 32.4 | 20.56 | 10.2 | .01 | .08 |
| | | 25 | 5.7 | 32.8 | 25.88 | 8.7 | .02 | .05 | | 25 | 5.6 | 32.8 | 25.89 | 7.6 | .02 | .05 |
| | | 26* | 5.5 | 32.8 | 25.90 | 7.2 | .01 | .06 | | 33* | 5.5 | 32.8 | 25.90 | 6.8 | .03 | .08 |
| 19 | 0950 | 1 | 5.7 | 27.6 | 21.77 | 11.6 | <.01 | .01 | 1550 | 1 | 6.0 | 28.3 | 22.30 | 11.2 | <.01 | .01 |
| | | 10 | 5.7 | 32.5 | 25.61 | 9.8 | .01 | .02 | | 10 | 5.9 | 32.0 | 25.23 | 9.8 | .03 | .03 |
| | | 12* | 5.8 | 32.5 | 25.63 | 9.7 | .03 | .09 | | 12* | 5.9 | 32.8 | 25.87 | 8.2 | .03 | .04 |
| 20 | 0915 | 1 | 5.7 | 27.0 | 21.30 | 10.6 | .02 | .02 | 1520 | 1 | 6.0 | 19.2 | 23.01 | 11.4 | <.01 | .01 |
| | | 10 | 5.9 | 32.0 | 25.23 | 10.3 | .08 | .03 | | 10 | 5.9 | 32.4 | 25.55 | 9.6 | .15 | .05 |
| | | 24* | 6.0 | 32.8 | 25.84 | 3.7 | .46 | .09 | | 16* | 5.9 | 32.8 | 25.37 | 2.1 | 2.0 | .31 |
| 21 | 1005 | 1 | 5.6 | 28.7 | 22.65 | 11.5 | <.01 | .02 | 1551 | 1 | 5.9 | 23.3 | 18.38 | 11.3 | <.01 | .02 |
| | | 10 | 6.8 | 32.4 | 25.43 | 10.4 | .02 | .03 | | 10 | 5.8 | 32.0 | 25.24 | 9.6 | .03 | .03 |
| | | 16* | 5.8 | 32.4 | 25.55 | 9.7 | .05 | .06 | | 15* | 5.8 | 32.4 | 25.56 | 9.2 | .04 | .05 |
| 22 | 1010 | 1 | 5.9 | 31.3 | 24.68 | 10.8 | .01 | .02 | 1555 | 1 | 6.0 | 32.0 | 25.21 | 10.3 | <.01 | .02 |
| | | 8* | 5.9 | 32.4 | 25.55 | 10.0 | .10 | .22 | | 10* | 5.9 | 32.4 | 25.55 | 9.6 | .19 | .29 |
| 23 | 1015 | 1 | 5.8 | 28.7 | 22.63 | 11.1 | <.01 | .02 | 1600 | 1 | 5.9 | 30.9 | 24.36 | 10.5 | — | — |
| | | 10 | 5.8 | 32.8 | 25.87 | 10.4 | .02 | .03 | | 10 | 5.8 | 32.4 | 25.56 | 9.8 | — | — |
| | | 25 | 5.7 | 32.8 | 25.88 | 4.5 | .46 | .15 | | 25 | 5.7 | 32.8 | 25.88 | 7.8 | — | — |
| | | 28* | 5.7 | 32.8 | 25.88 | 4.2 | — | — | | 27* | 5.7 | 32.8 | 25.88 | 5.0 | — | — |
| 24 | 1035 | 1 | 5.6 | 30.9 | 24.38 | 10.9 | .03 | .03 | 1610 | 1 | 5.9 | 31.6 | 24.91 | 10.8 | <.01 | .03 |
| | | 10 | 5.7 | 32.4 | 25.57 | 10.4 | .02 | .03 | | 10 | 5.8 | 32.4 | 25.56 | 10.2 | .02 | .07 |
| | | 25 | 5.8 | 32.8 | 25.88 | 5.8 | .29 | .08 | | 25 | 5.7 | 32.8 | 25.58 | 8.9 | .02 | .08 |
| | | 28* | 5.7 | 32.8 | 25.87 | 4.0 | .50 | .31 | | 31* | 5.7 | 32.8 | 25.58 | 4.1 | .41 | .14 |

TABLE 3 (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 19, 1976

| | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l |
| 25 | 1050 | 1 | 5.8 | 32.4 | 25.56 | 10.7 | <.01 | .03 | 1620 | 1 | 6.0 | 30.6 | 24.10 | 10.7 | — | — |
| | | 10 | 5.8 | 32.8 | 25.87 | 9.8 | .03 | .03 | | 10 | 5.9 | 32.8 | 25.86 | 10.1 | — | — |
| | | 25 | 5.8 | 32.8 | 25.87 | 6.0 | .31 | .08 | | 25 | 5.9 | 32.8 | 25.86 | 8.4 | — | — |
| | | 30* | 5.7 | 32.8 | 25.88 | 5.1 | 2.0 | 1.6 | | 31* | 5.7 | 32.8 | 25.86 | 5.8 | — | — |
| 26 | 1105 | 1 | 5.8 | 31.6 | 24.92 | 10.8 | <.01 | .02 | 1622 | 1 | 6.0 | 29.8 | 23.48 | 11.0 | — | — |
| | | 10 | 5.9 | 32.8 | 25.86 | 10.7 | .02 | .03 | | 10 | 5.9 | 32.4 | 25.55 | 10.2 | — | — |
| | | 25 | 5.9 | 32.8 | 25.86 | 7.2 | .32 | .09 | | 25 | 5.7 | 32.8 | 25.88 | 7.6 | — | — |
| | | 36* | 5.6 | 32.8 | 25.89 | 4.3 | .47 | .14 | | 37* | 5.7 | 32.8 | 25.88 | 3.6 | — | — |
| 27 | 1120 | 1 | 5.9 | 31.6 | 24.91 | 10.9 | <.01 | .02 | 1630 | 1 | 6.0 | 30.6 | 24.10 | 10.9 | <.01 | .02 |
| | | 10 | 5.8 | 32.4 | 25.56 | 10.4 | .02 | .04 | | 10 | 5.9 | 32.4 | 25.55 | 10.2 | .03 | .03 |
| | | 25 | 5.8 | 32.8 | 25.87 | 7.3 | .30 | .08 | | 25 | 5.7 | 32.8 | 25.88 | 9.4 | .31 | .10 |
| | | 40* | 5.7 | 32.8 | 25.88 | 4.5 | .46 | .14 | | 37 | 5.7 | 32.0 | 25.23 | 4.2 | .49 | .19 |
| 28 | 1145 | 1 | 5.9 | 26.9 | 21.20 | 11.2 | <.01 | .02 | 1645 | 1 | 6.0 | 32.0 | 25.21 | 10.8 | <.01 | .02 |
| | | 10 | 5.8 | 32.8 | 25.87 | 10.4 | .03 | .05 | | 10 | 5.8 | 32.4 | 25.55 | 10.3 | <.01 | .03 |
| | | 25 | 5.7 | 32.8 | 25.88 | 9.9 | <.01 | .03 | | 25 | 5.8 | 32.8 | 25.87 | 9.0 | .25 | .08 |
| | | 38* | 5.6 | 32.8 | 25.89 | 4.5 | 2.3 | 1.3 | | 36* | 5.7 | 32.8 | 25.88 | 4.4 | .45 | .14 |
| 29 | 1155 | 1 | 5.8 | 32.4 | 25.56 | 11.0 | <.01 | .02 | 1652 | 1 | 6.0 | 31.6 | 24.89 | 10.8 | — | — |
| | | 10 | 5.7 | 32.4 | 25.57 | 10.7 | .01 | .03 | | 10 | 5.8 | 32.4 | 25.56 | 10.4 | — | — |
| | | 25 | 5.6 | 32.8 | 25.89 | 9.5 | .30 | .09 | | 25 | 5.8 | 32.8 | 25.87 | 6.0 | — | — |
| | | 34* | 5.6 | 32.8 | 25.89 | 4.2 | .56 | .22 | | 33* | 5.7 | 32.8 | 25.88 | 4.2 | — | — |
| 30 | 1210 | 1 | 5.9 | 32.0 | 25.23 | 10.9 | <.01 | .02 | 1658 | 1 | 6.0 | 32.0 | 25.21 | 10.7 | <.01 | .02 |
| | | 10 | 5.8 | 32.8 | 25.87 | 10.1 | <.01 | .02 | | 10 | 5.9 | 32.4 | 25.55 | 10.5 | <.01 | .02 |
| | | 25* | 5.6 | 32.8 | 25.89 | 9.7 | <.01 | .03 | | 25* | 5.7 | 32.8 | 25.88 | 9.6 | <.01 | .03 |

TABLE 3 (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 19, 1976

| | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l |
| 31 | 1225 | 1 | 5.9 | 31.6 | 24.91 | 10.9 | <.01 | .02 | 1710 | 1 | 5.9 | 31.3 | 24.68 | 10.7 | — | — |
| | | 10 | 5.7 | 32.4 | 25.56 | 10.6 | <.01 | .02 | | 10 | 5.8 | 32.4 | 25.56 | 10.6 | — | — |
| | | 20* | 5.6 | 32.8 | 25.89 | 9.4 | <.01 | .03 | | 20 | 5.6 | 32.8 | 25.89 | 9.8 | — | — |
| 32 | 1305 | 1 | 5.8 | 32.0 | 25.40 | 10.8 | <.01 | .02 | 1745 | 1 | 5.9 | 32.0 | 25.23 | 10.8 | — | — |
| | | 10 | 5.8 | 32.4 | 25.55 | 10.5 | .03 | .04 | | 10 | 5.9 | 32.4 | 25.55 | 10.3 | — | — |
| | | 25 | 5.6 | 32.8 | 25.89 | 9.6 | <.01 | .03 | | 25 | 5.7 | 32.8 | 25.88 | 9.3 | — | — |
| | | 34* | 5.6 | 32.8 | 25.89 | 3.9 | .40 | .13 | | 33* | 5.7 | 32.8 | 25.88 | 5.1 | — | — |
| 33 | 1325 | 1 | 5.8 | 32.0 | 25.24 | 10.8 | <.01 | .02 | 1750 | 1 | 6.0 | 31.3 | 24.65 | 11.0 | — | — |
| | | 10 | 5.8 | 32.4 | 25.55 | 10.5 | .02 | .03 | | 10 | 5.8 | 32.4 | 25.56 | 10.0 | — | — |
| | | 25 | 5.7 | 32.8 | 25.98 | 6.7 | .30 | .09 | | 25 | 5.8 | 32.8 | 25.87 | 7.6 | — | — |
| | | 30* | 5.7 | 32.8 | 25.98 | 4.3 | .40 | .13 | | 30* | 5.7 | 32.8 | 25.88 | 4.1 | — | — |
| 34 | 1340 | 1 | 5.9 | 32.4 | 25.55 | 10.8 | <.01 | .03 | 1800 | 1 | 6.0 | 32.4 | 25.21 | 10.6 | <.01 | .03 |
| | | 10 | 5.8 | 32.4 | 25.56 | 10.2 | .02 | .04 | | 10 | 5.8 | 32.4 | 25.56 | 9.6 | .04 | .04 |
| | | 25 | 5.8 | 32.8 | 25.87 | 9.5 | .15 | .06 | | 25 | 5.7 | 32.8 | 25.88 | 7.0 | .06 | .04 |
| | | 36* | 5.7 | 32.8 | 25.88 | 3.9 | .41 | .16 | | 34* | 5.7 | 32.8 | 25.88 | 5.1 | .39 | .16 |
| 35 | 1350 | 1 | 6.0 | 32.4 | 25.52 | 10.2 | .03 | .10 | 1810 | 1 | 6.1 | 31.6 | 24.88 | 10.0 | .01 | .04 |
| | | 10 | 5.8 | 32.4 | 25.56 | 9.9 | .03 | .04 | | 10 | 5.8 | 32.4 | 25.56 | 9.4 | .06 | .06 |
| | | 24* | 5.8 | 32.8 | 25.87 | 8.0 | 3.8 | 1.3 | | 24* | 5.8 | 32.8 | 25.87 | 7.2 | .20 | .14 |
| 36 | 1352 | 1 | 5.9 | 32.4 | 25.55 | 10.9 | <.01 | .04 | 1820 | 1 | 6.0 | 32.4 | 25.21 | 10.7 | — | — |
| | | 10 | 5.8 | 32.4 | 25.56 | 10.6 | .03 | .04 | | 10 | 5.7 | 32.8 | 25.88 | 9.9 | — | — |
| | | 25 | 5.7 | 32.8 | 25.88 | 7.0 | .21 | .07 | | 25 | 5.7 | 32.8 | 25.88 | 8.5 | — | — |
| | | 37* | 5.7 | 32.8 | 25.88 | 4.5 | .41 | .13 | | 36* | 5.6 | 32.8 | 25.89 | 3.9 | — | — |
| 37 | 1359 | 1 | 5.9 | 31.3 | 25.68 | 10.0 | .04 | .07 | 1830 | 1 | 6.0 | 32.4 | 25.21 | 10.4 | .05 | .06 |
| | | 10 | 5.8 | 31.6 | 24.92 | 9.3 | .05 | .04 | | 10 | 5.8 | 32.8 | 25.87 | 9.1 | .09 | .05 |
| | | 16* | 5.7 | 32.8 | 25.88 | 8.5 | .20 | .20 | | 16* | 5.7 | 32.8 | 25.88 | 7.6 | .24 | .11 |

TABLE 3A

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 24, 1976

| | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | Time | Depth 1/ | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l |
| 1 | 1330 | 1 | 5.7 | 31.6 | 24.93 | 10.3 | <.01 | .02 | 0905 | 1 | 5.5 | 28.3 | 22.37 | 10.5 | <.01 | .02 |
| | | 10 | 5.6 | 32.4 | 25.58 | 9.8 | <.01 | .02 | | 10 | 5.8 | 32.8 | 25.87 | 9.7 | <.01 | .02 |
| | | 25 | 5.6 | 32.8 | 25.89 | 8.7 | .02 | .05 | | 25 | 5.7 | 32.8 | 25.88 | 8.7 | .03 | .05 |
| | | 55* | 4.2 | 32.8 | 26.04 | 3.8 | .04 | .06 | | 47* | 4.7 | 32.8 | 25.99 | 5.8 | .01 | .06 |
| 2 | 1315 | 1 | 5.7 | 30.9 | 24.38 | 10.3 | <.01 | .02 | 0855 | 1 | 5.9 | 32.0 | 25.23 | 10.2 | <.01 | .02 |
| | | 10 | 5.7 | 32.8 | 25.88 | 8.9 | <.01 | .02 | | 10 | 5.8 | 32.8 | 25.87 | 9.4 | <.01 | .02 |
| | | 20 | 5.6 | 32.8 | 25.89 | 8.6 | .23 | .08 | | 20 | 5.8 | 32.8 | 25.87 | 8.5 | .23 | .08 |
| 3 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| 4 | 1300 | 1 | 5.8 | 31.3 | 24.69 | 11.0 | <.01 | .02 | 0845 | 1 | 5.7 | 31.3 | 24.70 | 10.8 | <.01 | .02 |
| | | 10 | 5.7 | 32.8 | 25.88 | 10.0 | <.01 | .02 | | 10 | 5.8 | 32.8 | 25.87 | 10.0 | <.01 | .02 |
| | | 25 | 5.6 | 32.8 | 25.89 | 8.7 | <.01 | .03 | | 25 | 5.7 | 32.8 | 25.88 | 8.8 | <.01 | .04 |
| | | 50 | — | — | — | — | — | — | | 50 | — | — | — | — | <.01 | .10 |
| | | 60 | 3.5 | 32.8 | 26.12 | 3.0 | <.01 | .08 | | 60 | 3.9 | 32.8 | 26.08 | 3.2 | — | — |
| | | 75 | — | — | — | — | — | — | | 75 | — | — | — | — | — | — |
| | | 80* | — | — | — | — | — | — | | 80 | — | — | — | — | — | — |
| 7 | 1245 | 1 | 5.6 | 30.6 | 24.16 | 10.7 | <.01 | .01 | 0820 | 1 | 5.8 | 31.3 | 24.69 | 10.6 | <.01 | .02 |
| | | 10 | 5.7 | 32.8 | 25.88 | 9.9 | <.01 | .02 | | 10 | 5.8 | 32.8 | 25.87 | 9.9 | <.01 | .02 |
| | | 25 | 5.7 | 32.8 | 25.88 | 8.6 | <.01 | .04 | | 25 | 5.7 | 32.8 | 25.88 | 8.6 | <.01 | .03 |
| | | 50 | 4.5 | 32.8 | 26.01 | — | <.01 | .07 | | 50 | 4.7 | 32.8 | 25.99 | — | <.01 | .10 |
| | | 75 | — | — | — | — | — | — | | 75 | — | — | — | — | — | — |
| | | 100 | 3.3 | 32.8 | 26.15 | 2.3 | — | — | | 100 | 3.1 | 32.8 | 26.16 | 2.3 | — | — |
| | | 107 | — | — | — | — | — | — | | 107 | — | — | — | — | — | — |

1/ Meters

* Depth to bottom

TABLE 3A (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 24, 1976

| | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Station No. | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l |
| 8 | 1240 | 1 | 5.6 | 29.8 | 23.51 | 10.6 | .01 | .02 | 0810 | 1 | 5.7 | 31.6 | 24.93 | 10.5 | <.01 | .02 |
| | | 10 | 5.7 | 32.4 | 25.57 | 10.2 | <.01 | .03 | | 10 | 5.8 | 32.8 | 25.87 | 10.0 | <.01 | .02 |
| | | 17 | 5.7 | 32.8 | 25.88 | 9.4 | — | — | | 20 | 5.8 | 32.8 | 25.87 | 9.4 | <.01 | .04 |
| 9 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| | | — | — | — | — | — | — | — | | — | — | — | — | — | — | — |
| 14 | 1225 | 1 | 5.6 | 30.9 | 25.38 | 10.7 | <.01 | .01 | 0800 | 1 | 5.8 | 32.0 | 25.24 | 10.6 | <.01 | .02 |
| | | 10 | 5.7 | 32.8 | 25.88 | 10.0 | <.01 | .03 | | 10 | 5.6 | 32.8 | 25.89 | 9.7 | <.01 | .03 |
| | | 14* | 5.7 | 32.8 | 25.88 | 9.1 | .06 | .04 | | 16 | 5.6 | 32.8 | 25.89 | 9.3 | <.01 | .02 |
| 16 | 1220 | 1 | 5.7 | 31.3 | 24.70 | 10.2 | <.01 | .01 | 0745 | 1 | 5.7 | 31.6 | 24.93 | 10.7 | <.01 | .01 |
| | | 10 | 5.7 | 32.4 | 25.57 | 10.2 | <.01 | .02 | | 10 | 5.8 | 32.8 | 25.87 | 10.1 | <.01 | .02 |
| | | 20* | 5.7 | 32.8 | 25.88 | 9.5 | <.01 | .03 | | 20* | 5.8 | 32.8 | 25.87 | 9.4 | <.01 | .02 |
| 17 | 1540 | 1 | 5.7 | 32.4 | 25.58 | 10.4 | <.01 | .01 | 1120 | 1 | 5.7 | 32.4 | 25.57 | 10.3 | <.01 | .01 |
| | | 10 | 5.7 | 32.4 | 25.58 | 10.3 | <.01 | .02 | | 10 | 5.7 | 32.4 | 25.57 | 10.3 | <.01 | .01 |
| | | 25 | 5.7 | 32.8 | 25.88 | 10.0 | <.01 | .03 | | 25 | 5.7 | 32.8 | 25.88 | 9.9 | <.01 | .02 |
| | | 44* | 5.7 | 32.8 | 25.88 | 9.3 | <.01 | .04 | | 42* | 5.6 | 32.8 | 25.89 | 8.9 | <.01 | .04 |

TABLE 3A (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 24, 1976

| Station No. | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/1 | $NH_3$ mg/1 | TP mg/1 | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/1 | $NH_3$ mg/1 | TP mg/1 |
| 18 | 1340 | 1 | 5.5 | 29.8 | 23.55 | 9.8 | .02 | .01 | 0920 | 1 | 5.9 | 32.0 | 25.23 | 9.6 | .09 | .04 |
| | | 10 | 5.6 | 32.4 | 25.58 | 9.5 | <.01 | .03 | | 10 | 5.8 | 32.8 | 25.87 | 9.3 | <.01 | .03 |
| | | 25* | 5.6 | 32.8 | 25.89 | 7.2 | .21 | .09 | | 25* | 5.6 | 32.8 | 25.89 | 7.4 | .07 | .06 |
| 19 | 1345 | 1 | 5.6 | 31.3 | 24.71 | 9.1 | .05 | .03 | 0940 | 1 | 5.9 | 28.7 | 22.63 | 9.2 | .04 | .03 |
| | | 10* | 5.8 | 32.8 | 25.87 | 8.8 | <.01 | .03 | | 10* | 5.8 | 32.8 | 25.87 | 8.7 | .01 | .03 |
| 20 | 1350 | 1 | 6.0 | 31.3 | 24.65 | 8.1 | .12 | .04 | 0945 | 1 | 5.9 | 29.8 | 23.48 | 8.3 | .15 | .03 |
| | | 10 | 5.7 | 32.8 | 25.88 | 6.3 | .21 | .06 | | 10 | 5.8 | 32.8 | 25.87 | 7.0 | .18 | .05 |
| | | 17* | 5.6 | 32.8 | 25.89 | 3.9 | .42 | .24 | | 17* | 5.8 | 32.8 | 25.87 | 0.0 | 1.9 | .23 |
| 21 | 1400 | 1 | 5.8 | 32.0 | 25.24 | 8.9 | .08 | .04 | 0955 | 1 | 5.7 | 30.2 | 23.83 | 9.3 | .04 | .03 |
| | | 10 | 5.7 | 32.4 | 25.57 | 8.1 | .03 | .04 | | 10 | 5.8 | 32.8 | 25.87 | 8.7 | .04 | .04 |
| | | 25* | 5.6 | 32.8 | 25.89 | 7.8 | .12 | .09 | | 20* | 5.7 | 32.8 | 25.88 | 7.8 | .09 | .05 |
| 22 | 1410 | 1 | 5.7 | 31.3 | 24.70 | 8.9 | .06 | .11 | 1005 | 1 | 5.7 | 31.6 | 24.93 | 9.2 | .06 | .04 |
| | | 10* | 5.7 | 32.8 | 25.88 | 7.8 | .38 | .05 | | 7* | 5.7 | 32.0 | 25.25 | 8.4 | .20 | .08 |
| 23 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | | -- | -- | -- | -- | -- | -- | -- | | -- | -- | -- | -- | -- | -- | -- |
| | | -- | -- | -- | -- | -- | -- | -- | | -- | -- | -- | -- | -- | -- | -- |
| | | -- | -- | -- | -- | -- | -- | -- | | -- | -- | -- | -- | -- | -- | -- |
| 24 | 1420 | 1 | 5.7 | 31.6 | 24.93 | 9.6 | .02 | .02 | 1010 | 1 | 5.7 | 32.0 | 25.25 | 10.1 | .02 | .02 |
| | | 10 | 5.7 | 32.8 | 25.88 | 9.2 | <.01 | .03 | | 10 | 5.7 | 32.4 | 25.57 | 9.7 | <.01 | .03 |
| | | 25 | 5.6 | 32.8 | 25.89 | 7.8 | .22 | .07 | | 25 | 5.6 | 32.8 | 25.58 | 8.0 | .15 | .06 |
| | | 33* | 5.6 | 32.8 | 25.89 | 3.7 | .41 | .13 | | 32* | 5.6 | 32.8 | 25.58 | 3.5 | .42 | .11 |

TABLE 3A (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 24, 1976

| Station No. | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/l | $NH_3$ mg/l | TP mg/l |
| 25 | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | |
| 27 | 1430 | 1 | 5.7 | 30.6 | 24.14 | 10.0 | .03 | .03 | 1025 | 1 | 5.6 | 31.3 | 24.71 | 10.2 | .01 | .02 |
| | | 10 | 5.7 | 32.4 | 25.24 | 9.7 | .02 | .05 | | 10 | 5.7 | 32.4 | 25.67 | 10.0 | .01 | .03 |
| | | 25 | 5.7 | 32.8 | 25.88 | 8.1 | .15 | .06 | | 25 | 5.6 | 32.8 | 25.89 | 7.8 | .10 | .05 |
| | | 38* | 5.7 | 32.8 | 25.88 | 3.7 | .41 | .13 | | 39* | 5.6 | 32.8 | 25.89 | 4.0 | .40 | .14 |
| 28 | 1440 | 1 | 5.6 | 30.6 | 24.15 | 10.0 | .05 | .02 | 1035 | 1 | 5.5 | 31.3 | 24.72 | 10.2 | .01 | .02 |
| | | 10 | 5.6 | 32.4 | 25.89 | 10.1 | <.01 | .04 | | 10 | 5.7 | 32.4 | 24.57 | 10.1 | .01 | .03 |
| | | 25 | 5.6 | 32.8 | 25.89 | 8.0 | .16 | .07 | | 25 | 5.6 | 32.8 | 25.89 | 7.6 | .10 | .05 |
| | | 38* | 5.6 | 32.8 | 25.89 | 3.9 | .39 | .13 | | 39* | 5.6 | 32.8 | 25.89 | 3.8 | .40 | .14 |
| 29 | | | | | | | | | | | | | | | | |
| 30 | 1525 | 1 | 5.7 | 32.0 | 25.25 | 10.2 | <.01 | .02 | 1105 | 1 | 5.5 | 31.6 | 24.95 | 10.4 | <.01 | .02 |
| | | 10 | 5.8 | 32.4 | 25.56 | 10.3 | <.01 | .02 | | 10 | 5.7 | 32.4 | 25.57 | 10.2 | .10 | .05 |
| | | 25* | 5.8 | 32.8 | 25.87 | 8.2 | <.01 | .02 | | 25* | 5.6 | 32.8 | 25.89 | 9.5 | <.01 | .03 |

TABLE 3A (cont.)

SALINITY/DENSITY/DISSOLVED OXYGEN/AMMONIA NITROGEN ($NH_3$-N)/TOTAL PHOSPHORUS (TP)
DUTCH HARBOR, ALASKA
OCTOBER 24, 1976

| Station No. | FLOODING TIDE | | | | | | | | EBBING TIDE | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/1 | $NH_3$ mg/1 | TP mg/1 | Time | Depth | °C Temp | Salinity (°/oo) | Density (σt) | D.O. mg/1 | $NH_3$ mg/1 | TP mg/1 |
| 31 | | | | | | | | | | | | | | | | |
| 32 | | | | | | | | | | | | | | | | |
| 33 | | | | | | | | | | | | | | | | |
| 34 | 1445 | 1 | 5.6 | 31.3 | 24.71 | 10.2 | .04 | .02 | 1045 | 1 | 5.5 | 31.3 | 24.72 | 9.6 | .03 | .02 |
| | | 10 | 5.7 | 32.4 | 25.58 | 10.0 | <.01 | .02 | | 10 | 5.7 | 32.4 | 25.57 | 10.0 | <.01 | .02 |
| | | 25 | 5.6 | 32.8 | 25.89 | 8.4 | .13 | .05 | | 25 | 5.6 | 32.8 | 25.89 | 8.0 | .13 | .05 |
| | | 30* | 5.6 | 32.8 | 25.89 | 3.9 | .50 | .65 | | 35* | 5.6 | 32.8 | 25.89 | 3.8 | 2.2 | .90 |
| 35 | 1455 | 1 | 5.8 | 31.6 | 24.92 | 9.5 | .04 | .04 | 1050 | 1 | 5.6 | 31.3 | 24.71 | 9.6 | .25 | .05 |
| | | 10 | 5.7 | 32.4 | 25.58 | 9.3 | .01 | .03 | | 10 | 5.7 | 32.0 | 25.26 | 9.3 | .03 | .05 |
| | | 24* | 5.6 | 32.8 | 25.89 | 5.1 | .47 | .17 | | 24* | 5.7 | 32.8 | 25.88 | 5.5 | .96 | .23 |
| 36 | | | | | | | | | | | | | | | | |
| 37 | 1505 | 1 | 5.8 | 31.6 | 24.92 | 9.2 | .10 | .08 | — | — | — | — | — | — | — | — |
| | | 10 | 5.8 | 32.8 | 25.87 | 8.6 | .06 | .05 | | — | — | — | — | — | — | — |
| | | 20* | 5.8 | 32.8 | 25.87 | 6.7 | .18 | .08 | | — | — | — | — | — | — | — |

TABLE 4

ANALYTICAL RESULTS OF BOTTOM SEDIMENT SAMPLES
DUTCH HARBOR, ALASKA
OCTOBER 2, 1975

| Station | Location | Lab Number | Percent Volatile Solids | Percent Organic Matter | Chemical Oxygen Demand g/kg |
|---|---|---|---|---|---|
| 2 | Captain's Bay | Clean | Sand & Gravel | | |
| 18 | Captain's Bay | 41293 | 11.6 | 21.8 | 255 |
| 21a | Iliuliuk Harbor | 41200 | 16.6 | 20.4 | 240 |
| 21b | Iliuliuk Harbor | 41206 | 15.5 | 16.4 | 194 |
| 21c | Iliuliuk Harbor | 41208 | 6.9 | 2.2 | 25 |
| 22a | Iliuliuk Harbor | 41204 | 10.1 | 8.8 | 103 |
| 22 | Iliuliuk Bay | 41209 | 3.4 | 1.3 | 16 |
| 35 | Dutch Harbor | 41201 | 8.4 | 5.7 | 103 |
| 37 | Dutch Harbor | 41202 | 12.1 | 10.8 | 126 |
| 37a | Dutch Harbor | 41205 | 11.8 | 11.1 | 128 |
| 37b | Dutch Harbor | 41203 | 4.4 | 4.5 | 52 |
| 30 | Iliuliuk Bay | Clean | Sand & Gravel | | |
| 8a | Unalaska Bay | 41207 | 55.6 | 73.5 | 866 |

TABLE 5

ANALYTICAL RESULTS OF BOTTOM SEDIMENT SAMPLES
DUTCH HARBOR, ALASKA
OCTOBER 1976

| Water Quality Station No. | Location | Date | Time | Lab No. | COD g/kg dry wt. | Total Organic Nitrogen mg/g dry | Total Kjeldahl Nitrogen mg/g dry | Ammonia $NH_3$ mg/g dry | Percent Solids | Volatile Solids Percent | Percent Organic Matter | Organic* Sediment Classification |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Captain's Bay | 10/27/76 | 1105 | 44204 | 62.6 | 2.6 | 2.6 | .054 | 33.4 | 9.3 | 5.4 | 3 |
| 2 | Captain's Bay | 10/27/76 | 1120 | 44202 | 39.0 | 1.3 | 1.4 | .095 | 63.4 | 4.8 | 3.3 | 1 |
| 1 | Captain's Bay | 10/27/76 | 1137 | 44201 | 88.2 | 3.2 | 3.2 | .034 | 38.1 | 8.1 | 7.3 | 3 |
| 20 | Sub-Base | 10/27/76 | 0940 | 44220 | 171.5 | 5.8 | 6.5 | .72 | 27.7 | 13.8 | 14.4 | 3 |
| 21 | Iliuliuk Harbor | 10/27/76 | 1150 | 44221 | 76.8 | 2.6 | 2.7 | .10 | 44.9 | 6.9 | 6.5 | 3 |
| 24 | Iliuliuk Bay | 10/27/76 | 1203 | 44224 | 107.4 | 4.2 | 4.5 | .30 | 20.3 | 11.0 | 8.9 | 3 |
| 34 | Dutch Harbor | 10/27/76 | 1215 | 44234 | 117.6 | 3.7 | 4.0 | .32 | 17.0 | 11.8 | 10.0 | 3 |

*Type 1 - Inorganic or aged, stabilized organic deposits.

Type 2 - High carbon, little nitrogen contribution, slow oxygen demand.

Type 3 - Nitrogenous, substantial nitrogen contribution, further stabilization likely.

Type 4 - Actively decomposing sediments, high potential nitrogen release, and high oxygen demand.

TABLE 6

ANALYTICAL RESULTS OF EFFLUENT AND STREAM SAMPLES

| Source of Sample | Date | Time | Ammonia Nitrogen mg/l | Total Phosphorus mg/l | COD mg/l | Total Volatile Solids mg/l | Total Organic Carbon mg/l |
|---|---|---|---|---|---|---|---|
| Pan Alaska Seafoods | 10/22/76 | 1425 | 290 | 82 | 8,100 | 2,300 | 3,500 |
| M/V Eastpoint | 10/23/76 | 0905 | 52 | 110 | 6,800 | 4,400 | 1,400 |
| M/V Theresa Lee | 10/23/76 | 1500 | 1.8 | 9.5 | 2,600 | 1,100 | 300 |
| M/V Sea Alaska | 10/23/76 | 1345 | 1.4 | 9.4 | 1,700 | 4,600 | 380 |
| M/V Sea Producer | 10/23/76 | 1425 | 3.9 | 22 | 2,800 | 2,100 | 850 |
| M/V Whitney | 10/24/76 | 1045 | 1.7 | 9.5 | 1,300 | 3,200 | 160 |
| M/V Unisea | 10/24/76 | 1245 | 12 | 72 | 3,700 | 3,200 | 1,000 |
| M/V Vita & Viceroy | 10/24/76 | 1345 | 83 | 47 | 3,000 | 1,000 | 700 |
| Shaishnikof River | 10/25/76 | | <.01 | <.01 | -- | -- | -- |
| Iliuliuk River | 10/25/76 | | <.01 | <.01 | -- | -- | -- |

TABLE 7

OCTOBER 1976 DUTCH HARBOR CURRENT STUDIES
FLOOD TIDES

| Station No. | Date | Time | Elapsed Time | Drogue Depth | Direction of Travel | Distance Traveled Yards | Course Distances Yds | DIR | Velocity Knots | Overall Velocity | Start Location | End Location |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 10/22/76 | 0900 to 1410 | 5.16 | 10 | ENE Out of Unalaska B. | 2300 | 2300 | Z° | 0.22 | 0.22 | 53-54-32 166-33-21 | 53-55-38 166-32-45 |
| 14 | 10/22/76 | 1024 to 1515 | 4.84 | 1 | N | 1605 | 780<br>825 | 250°<br>332° | 0.14<br>0.19 | 0.16 | 53-53-23 116-32-54 | 53-53-45 166-33-43 |
| 14 | 10/22/76 | 1024 to 1526 | 5.03 | 10 | SSW | 360 | 250<br>110 | 220°<br>287° | 0.05<br>0.02 | 0.035 | 53-53-23 166-32-54 | 53-53-19 166-33-51 |
| 8 | 10/22/76 | 1015 to 1522 | 5.15 | 1 | N | 2260 | 300<br>1960 | 250°<br>345° | 0.05<br>0.43 | 0.24 | 53-52-55 166-33-25 | 53-53-49 166-33-51 |
| 8 | 10/22/76 | 1015 to 1507 | 4.90 | 10 | NNW | 1070 | 240<br>830 | 252°<br>340° | 0.04<br>0.20 | 0.12 | 53-52-55 166-32-25 | 53-53-19 166-33-51 |
| 9 | 10/20/76 | 0920 to 1450 | 5.5 | 1 | N | 940 | 940 | 242° | 0.09 | 0.09 | 53-53-22 166-35-08 | 53-53-49 166-35-07 |
| 9 | 10/20/76 | Lost 25 Meter Drogue | | | | | | | | | | |
| 9 | 10/22/76 | 1035 to 1447 | 4.19 | 1 | NNW | 3245 | 1100<br>920<br>1225 | 338°<br>359°<br>325° | 0.37<br>0.33<br>0.47 | 0.39 | 53-53-26 166-34-39 | 53-54-07 166-35-43 |
| 7 | 10/22/76 | 1005 to 1425 | 4.34 | 1 | NNW | 2765 | 1695<br>1070 | 335°<br>320° | 0.29<br>0.38 | 0.34 | 53-52-28 166-34-13 | 53-53-44 166-34-53 |

TABLE 7 (cont.)

OCTOBER 1976 DUTCH HARBOR CURRENT STUDIES
FLOOD TIDES

| Station No. | Date | Time | Elapsed Time | Drogue Depth | Direction of Travel | Distance Traveled Yards | Course Distances Yds | DIR | Velocity Knots | Overall Velocity | Start Location | End Location |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 10/22/76 | 1005 to 1410 | 4.08 | 25 | S into Captains Bay | 350 | 290 | 170° | 0.05 | | 53-52-28 166-34-13 | 53-52-19 166-34-14 |
| | | | | | | | 60 | 192° | 0.02 | 0.35 | | |
| 1 | 10/20/76 | 0945 to 1400 | 5.25 | 1 | E | 100 | 100 | 275° | <.01 | <.01 | 53-51-43 166-33-14 | Same Area |
| 1 | 10/20/76 | Same | 5.25 | 25 | Circular | 500 | Circled | | <.01 | <.01 | 11 | |
| 19 | 10/23/76 | 1055 to 1540 | 4.75 | 1 | South then North | 1010 | 260 | 172° | 0.08 | | 53-52-38 166-32-18 | 53-52-49 166-32-12 |
| | | | | | | | 470 | 190° | 0.43 | | | |
| | | | | | | | 100 | 87° | 0.04 | 0.16 | | |
| | | | | | | | 180 | 4° | 0.07 | | | |
| 19 | 10/23/76 | 1055 to 1528 | 4.55 | 10 | North then Return South | 710 | 30 | 355° | 0.02 | | 53-52-38 166-32-18 | 53-52-22 166-32-15 |
| | | | | | | | 240 | 8° | 0.12 | | | |
| | | | | | | | 240 | 327° | 0.09 | | | |
| | | | | | | | 200 | 222° | 0.08 | 0.08 | | |
| 24 | 10/23/76 | 1110 to 1547 | 4.62 | 1 | NE | 1540 | 140 | 0° | 0.07 | | 53-52-47 166-31-22 | 53-53-24 166-31-01 |
| | | | | | | | 525 | 20° | 0.26 | | | |
| | | | | | | | 525 | 25° | 0.20 | | | |
| | | | | | | | 350 | 305° | 0.14 | 0.17 | | |
| 24 | 10/23/76 | 1110 to 1556 | 4.8 | 25 | NW | 510 | 75 | 300° | 0.04 | | 53-52-47 166-31-22 | 53-52-55 166-31-38 |
| | | | | | | | 140 | 300° | 0.06 | | | |
| | | | | | | | 120 | 342° | 0.05 | | | |
| | | | | | | | 175 | 269° | 0.07 | 0.06 | | |
| 34 | 10/23/76 | 1119 to 1606 | 4.8 | 1 | N | 800 | 360 | 341° | 0.13 | | 53-53-52 166-31-20 | 53-54-14 166-31-32 |
| | | | | | | | 150 | 341° | 0.10 | | | |
| | | | | | | | 180 | 320° | 0.07 | | | |
| | | | | | | | 110 | 275° | 0.04 | 0.09 | | |

TABLE 7 (cont.)

OCTOBER 1976 DUTCH HARBOR CURRENT STUDIES
FLOOD TIDES

| Station No. | Date | Time | Elapsed Time | Drogue Depth | Direction of Travel | Distance Traveled Yards | Course Distances Yds | DIR | Velocity Knots | Overall Velocity | Start Location | End Location |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 10/23/76 | 1119 to 1604 | 4.8 | 25 | N | 800 | 360 | 347° | 0.13 | | 53-53-52 | 53-54-08 |
| | | | | | | | 240 | 67° | 0.16 | | 166-31-20 | 166-31-14 |
| | | | | | | | 170 | 302° | 0.07 | | | |
| | | | | | | | 30 | 338° | <.01 | 0.09 | | |
| 30 | 10/23/76 | 1135 to 1631 | 4.9 | 1 | NNE | 2010 | 375 | 47° | 0.19 | | 53-54-12 | 53-54-56 |
| | | | | | | | 875 | 293° | 0.32 | | 166-29-11 | 166-29-21 |
| | | | | | | | 370 | 2° | 0.16 | | | |
| | | | | | | | 390 | 352° | 0.14 | 0.20 | | |
| 30 | 10/23/76 | 1135 to 1625 | 4.9 | 25 | NNE | 1450 | 340 | 47° | 0.17 | | 53-54-12 | 53-54-39 |
| | | | | | | | 440 | 304° | 0.17 | | 166-29-11 | 166-29-05 |
| | | | | | | | 490 | 335° | 0.21 | | | |
| | | | | | | | 180 | 86° | 0.06 | 0.15 | | |

TABLE 7 (cont.)

OCTOBER 1976 DUTCH HARBOR CURRENT STUDIES
EBB TIDE

| Station No. | Date | Time | Elapsed Time Hours | Drogue Depth Meters | General Direction of Travel (Magnetic) | Distance Traveled Yards | Course Distances Yds DIR | Velocity Knots | Overall Velocity Knots | Start Location | End Location |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | 10/22/76 @ 1043 to 10/22/76 @ 1337 | | 2.73 | 1 | 351° N | 2,500 | 1200 @ 345°<br>1350 @ 357° | 0.41<br>0.52 | 0.46 | 53-54-32<br>166-33-25 | 53-55-50<br>166-33-13 |
| 16A | 10/26/76 @ 0915 to 10/26/76 @ 1318 | | 4.05 | 1 | 177° S Into Captains Bay from Unalaska Bay | 2,800 | 1125 @ 193°<br>650 @ 166°<br>1020 @ 166° | 0.49<br>0.27<br>0.71 | 0.49 | 53-53-32<br>166-33-27 | 53-52-12<br>166-33-54 |
| 16A | 10/26/76 | 0915 to 1300 | 3.75 | 25 | 170° S Towards Mouth of Captains Bay | 1,200 | 360 @ 267°<br>360 @ 168°<br>470 @ 135° | 0.16<br>0.15<br>0.16 | 0.16 | 53-53-32<br>166-33-27 | 53-53-11<br>166-33-32 |
| 9 | 10/26/76 | 0900 to 1242 | 3.7 | 1 | SE Towards Captains Bay | 1,360 | 320 @ 169°<br>430 @ 120°<br>610 @ 108° | 0.14<br>0.17<br>0.23 | 0.18 | 53-53-16<br>166-35-06 | 53-52-48<br>166-34-24 |
| 9 | 10/26/76 | 0900 to 1247 | 3.78 | 10 | S | 770 | 320 @ 169°<br>230 @ 171°<br>220 @ 260° | 0.14<br>0.10<br>0.06 | 0.10 | 53-53-16<br>166-35-06 | 53-53-01<br>166-35-14 |
| 7 | 10/26/76 | 0845 to 1206 | 3.35 | 1 | S | 4,300 | 1320 @ 190°<br>1100 @ 164°<br>1880 @ 210° | 0.62<br>0.52<br>0.76 | 0.63 | 53-52-17<br>166-34-13 | 53-50-29<br>166-35-44 |
| 7 | 10/26/76 | 0845 to 1227 | 3.7 | 10 | SSW | 1,215 | 480 @ 188°<br>110 @ 160°<br>625 @ 190° | 0.21<br>0.05<br>0.21 | 0.16 | 53-52-17<br>166-34-13 | 53-51-43<br>166-34-34 |

TABLE 7 (cont.)

OCTOBER 1976 DUTCH HARBOR CURRENT STUDIES
EBB TIDE

| Station No. | Date | Time | Elapsed Time Hours | Drogue Depth Meters | General Direction of Travel (Magnetic) | Distance Traveled Yards | Course Distances Yds DIR | Velocity Knots | Overall Velocity Knots | Start Location | End Location |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 10/26/76 | 0835 to 1152 | 3.22 | 1 | SW | 3,485 | 1225 @ 212°<br>700 @ 208°<br>1560 @ 225° | 0.54<br>0.36<br>0.69 | 0.53 | 53-51-46<br>166-33-37 | 53-50-39<br>166-35-38 |
| 1 | 10/26/76 | 0835-0930<br>1038-1326 | ≈4 | 10 | Circular Clockwise Vicinity Blakely Ledge | 430 | 180 @ 182°<br>70 @ 171°<br>180 @ 148° | 0.09<br>0.03<br>0.05 | 0.06 | 53-51-46<br>166-33-37 | 53-51-35<br>166-33-28 |
| 19 | 10/25/76 | 1035 to 1402 | 3.45 | 1 | N-S Move Through Iliuliuk Harbor and Back | 775 | 140 @ 044°<br>265 @ 4°<br>160 @ 189°<br>50 @ 224°<br>160 @ 183° | 0.06<br>0.13<br>0.11<br>0.03<br>0.12 | 0.11 | 53-52-39<br>166-32-43 | 53-52-38<br>166-32-41 |
| 19 | 10/25/76 | 1037 to 1442 | 4.08 | 10 | Circular Pattern Inside Harbor | 200 | Circular Buoy N2 | <0.01 | <0.01 | | |
| 24 | 10/25/76 | 0940 to 1255 | 3.25 | 1 | SSE Towards Shore @ Head of Iliuliuk Bay | 620 | 330 @ 123°<br>290 @ 134° | 0.16<br>0.12 | 0.14 | 53-52-52<br>166-31-22 | 53-52-38<br>166-31-04 |
| 24 | 10/25/76 | 0940 to 1335 | 3.92 | 10 | S Curving West | 700 | 225 @ 172°<br>275 @ 166°<br>75 @ 137°<br>125 @ 80° | 0.11<br>0.11<br>0.06<br>0.06 | 0.09 | 53-52-52<br>166-31-22 | 53-52-35<br>166-31-14 |
| 34 | 10/25/76 | 0952 to 1427 | 5.32 | 1 | E-W Back & Forth Across Entrance to Dutch Harbor | 775 | 225 @ 85°<br>290 @ 66°<br>160 @ 246°<br>100 @ 314° | 0.11<br>0.11<br>0.08<br>0.06 | 0.09 | 53-53-51<br>166-30-56 | 53-53-53<br>166-30-57 |

TABLE 7 (cont.)

OCTOBER 1976 DUTCH HARBOR CURRENT STUDIES
EBB TIDE

| Station No. | Date | Time | Elapsed Time Hours | Drogue Depth Meters | General Direction of Travel (Magnetic) | Distance Traveled Yards | Course Distances Yds @ DIR | Velocity Knots | Overall Velocity Knots | Start Location | End Location |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 10/25/76 | 0952 to 1342 | 3.88 | 10 | SE-NE (←——→) (Note Above) | 1,130 | 190 @ 130°<br>500 @ 124°<br>390 @ 323°<br>50 @ 67°<br>125 @ 17° | 0.09<br>0.20<br>0.20<br>0.03<br>0.10 | 0.09 | 53-53-51<br>166-30-56 | |
| 30 | 10/25/76 | 1004 to 1215 | 2.18 | 1 | E-W Back & Forth Across Entrance to Iliuliuk Bay | 1,140 | 540 @ 116°<br>600 @ 83° | 0.29<br>0.27 | 0.28 | 53-54-17<br>166-29-27 | 53-54-08<br>166-29-45 |
| 30 | 10/25/76 | 1004 to 1219 | 2.25 | 10 | NW Out of Bay | 460 | 230 @ 342°<br>230 @ 303° | 0.11<br>0.09 | 0.10 | 53-54-17<br>166-29-27 | 53-54-30<br>166-29-27 |

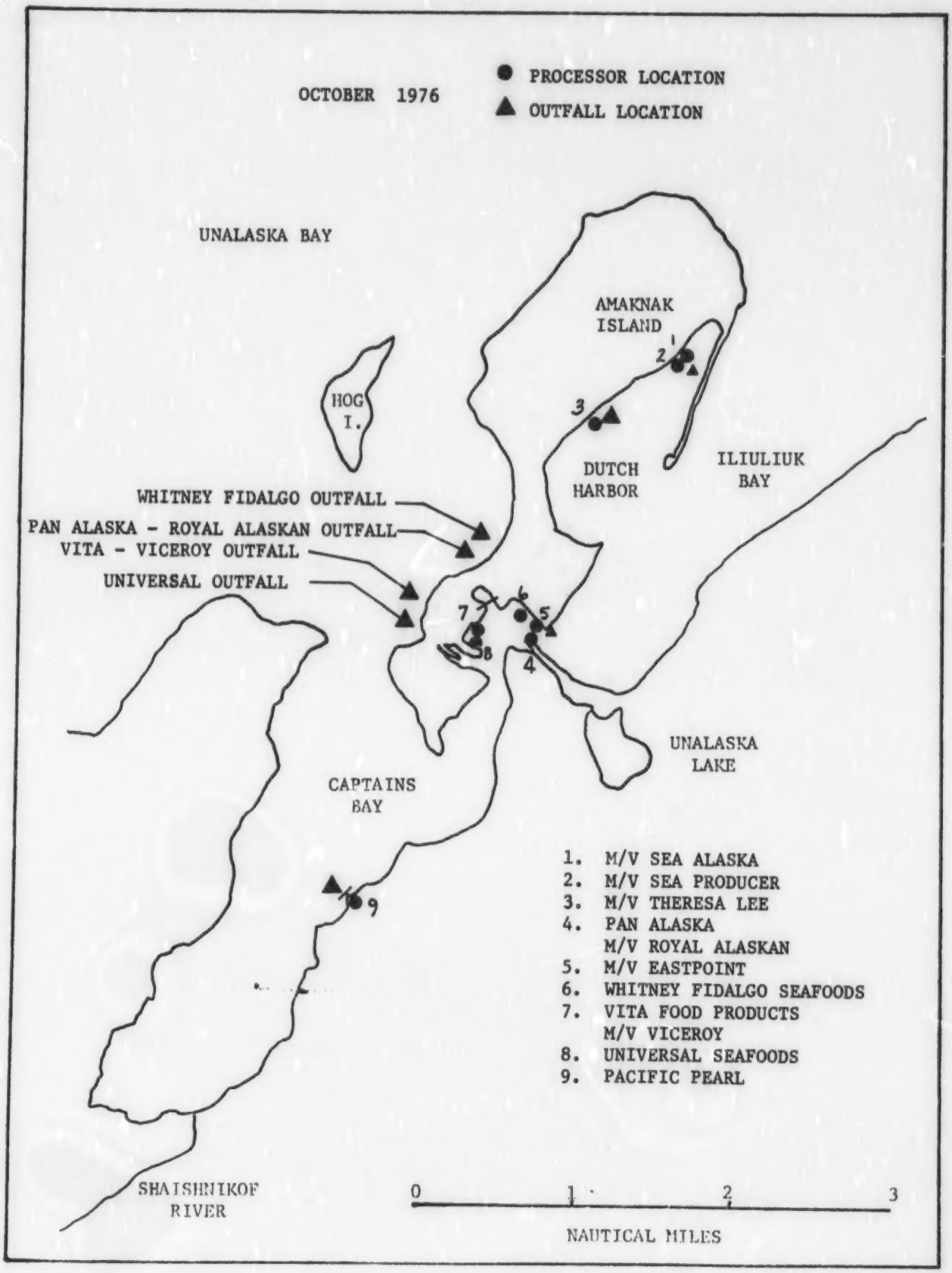

OCTOBER 1976
PROCESSOR LOCATION
OUTFALL LOCATION
UNALASKA BAY
AMAKNAK ISLAND
HOG I.
DUTCH HARBOR
ILIULIUK BAY
WHITNEY FIDALGO OUTFALL
PAN ALASKA - ROYAL ALASKAN OUTFALL
VITA - VICEROY OUTFALL
UNIVERSAL OUTFALL
UNALASKA LAKE
CAPTAINS BAY
SHAISHNIKOF RIVER
1. M/V SEA ALASKA
2. M/V SEA PRODUCER
3. M/V THERESA LEE
4. PAN ALASKA
M/V ROYAL ALASKAN
5. M/V EASTPOINT
6. WHITNEY FIDALGO SEAFOODS
7. VITA FOOD PRODUCTS
M/V VICEROY
8. UNIVERSAL SEAFOODS
9. PACIFIC PEARL
0 1 2 3
NAUTICAL MILES



FIGURE 2

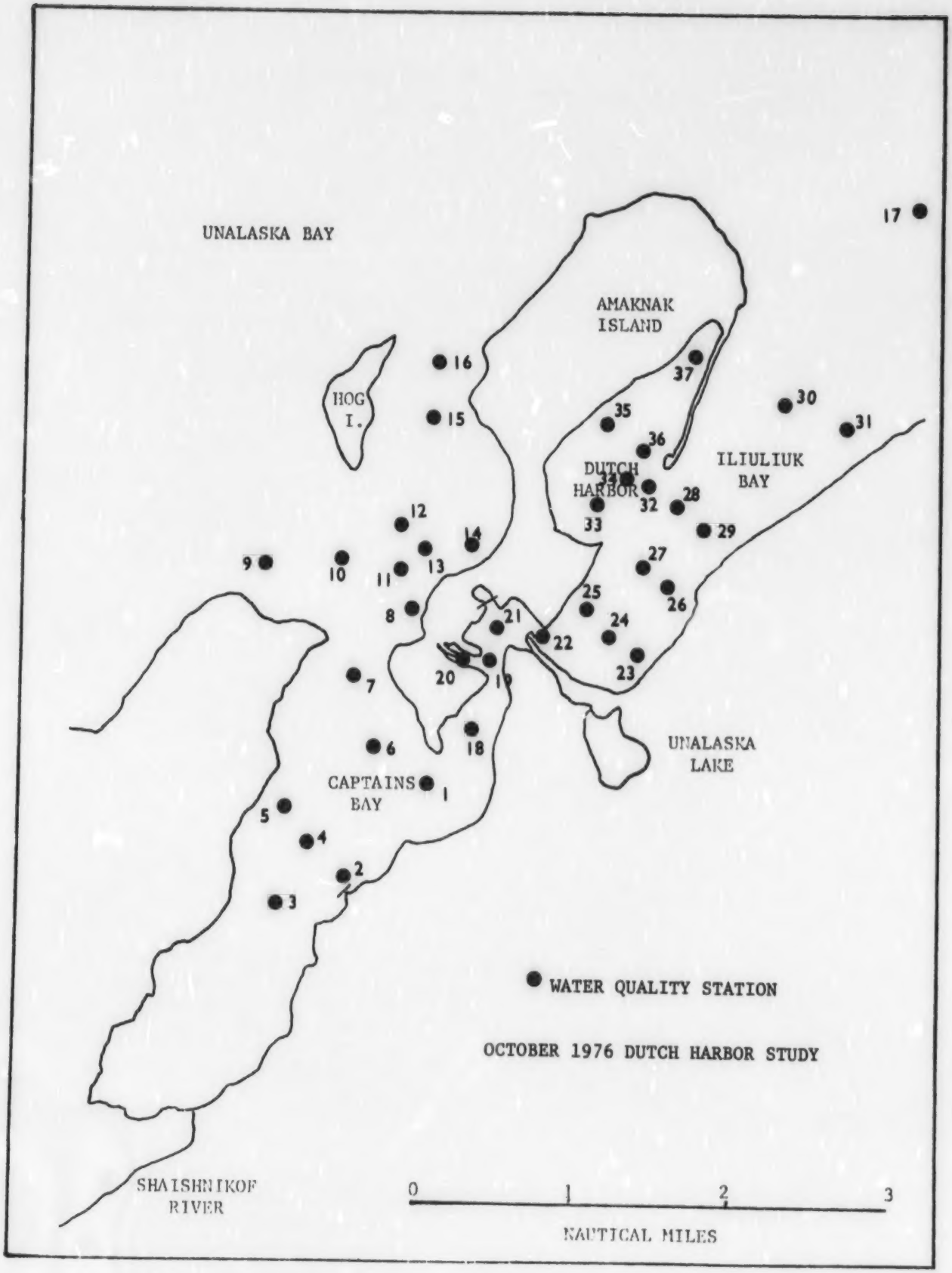

UNALASKA BAY
AMAKNAK ISLAND
HOG I.
DUTCH HARBOR
ILIULIUK BAY
CAPTAINS BAY
UNALASKA LAKE
SHAISHNIKOF RIVER
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
WATER QUALITY STATION
OCTOBER 1976 DUTCH HARBOR STUDY
0
1
2
3
NAUTICAL MILES



FIGURE 3

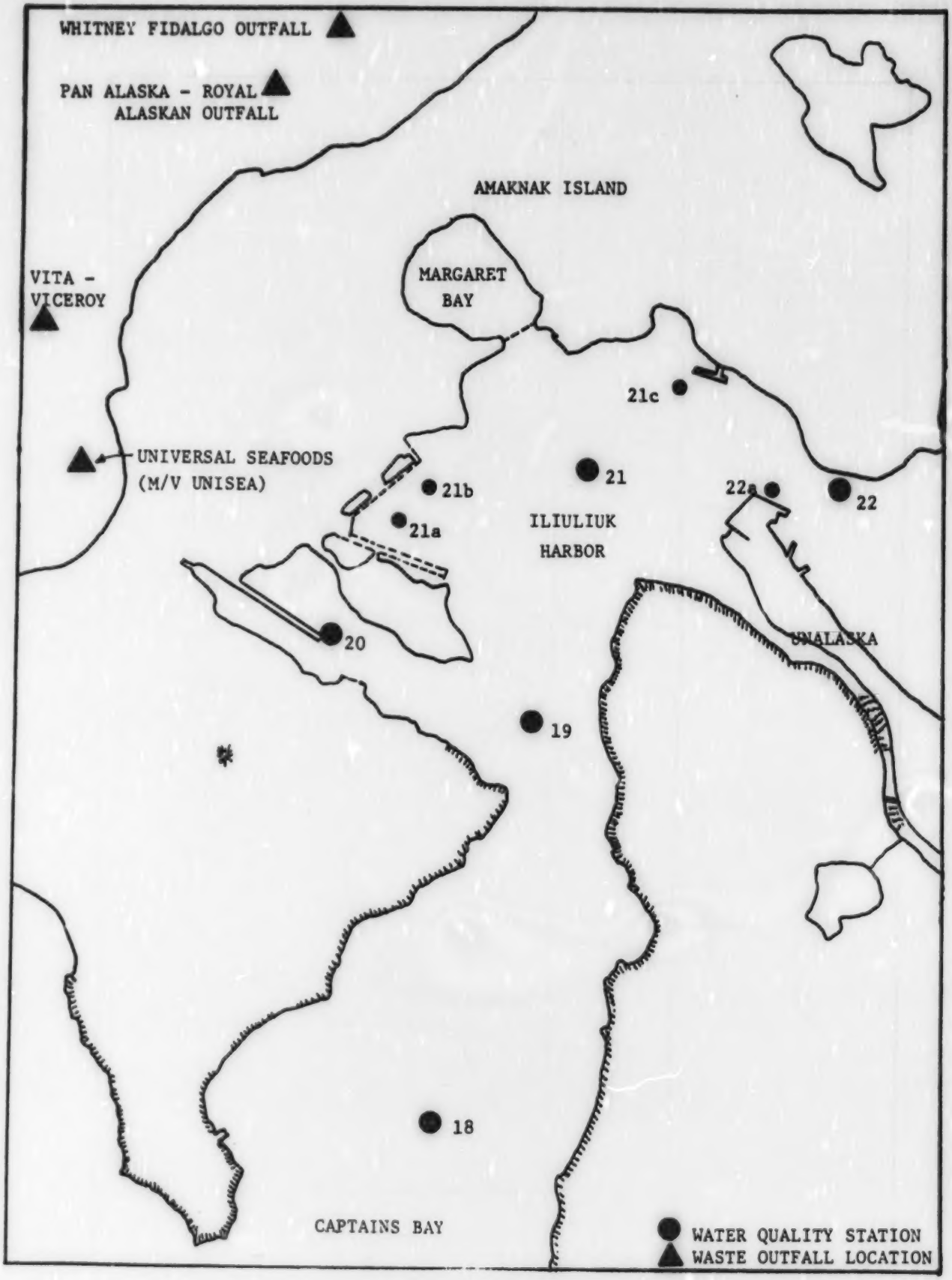
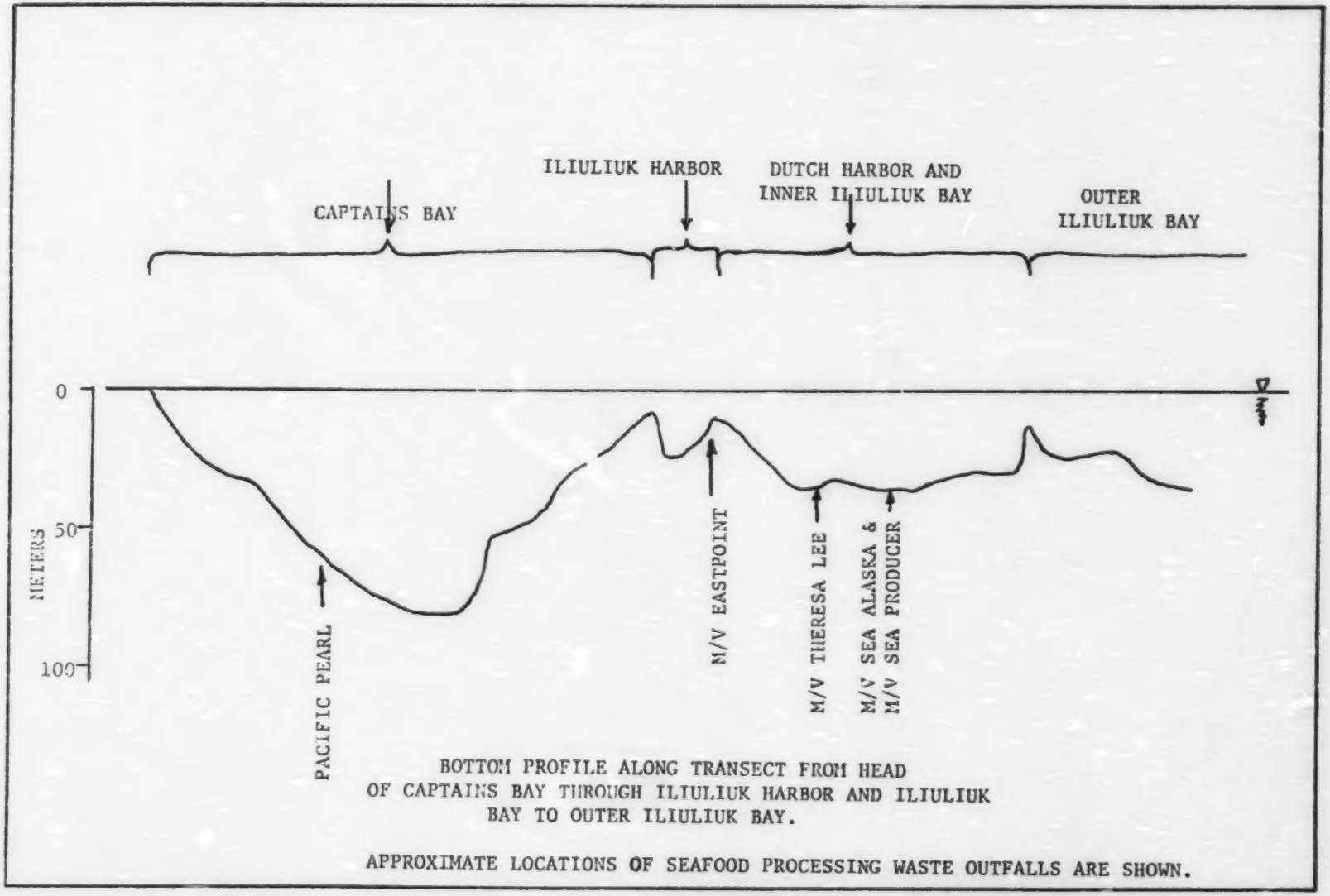

WHITNEY FIDALGO OUTFALL
PAN ALASKA - ROYAL ALASKAN OUTFALL
AMAKNAK ISLAND
VITA - VICEROY
MARGARET BAY
21c
UNIVERSAL SEAFOODS (M/V UNISEA)
21b
21
22a
22
21a
ILIULIUK HARBOR
20
UNALASKA
19
18
CAPTAINS BAY
WATER QUALITY STATION
WASTE OUTFALL LOCATION



FIGURE 4




BOTTOM PROFILE ALONG TRANSECT FROM HEAD OF CAPTAINS BAY THROUGH ILIULIUK HARBOR AND ILIULIUK BAY TO OUTER ILIULIUK BAY.

APPROXIMATE LOCATIONS OF SEAFOOD PROCESSING WASTE OUTFALLS ARE SHOWN.

FIGURE 5

FIGURE 5

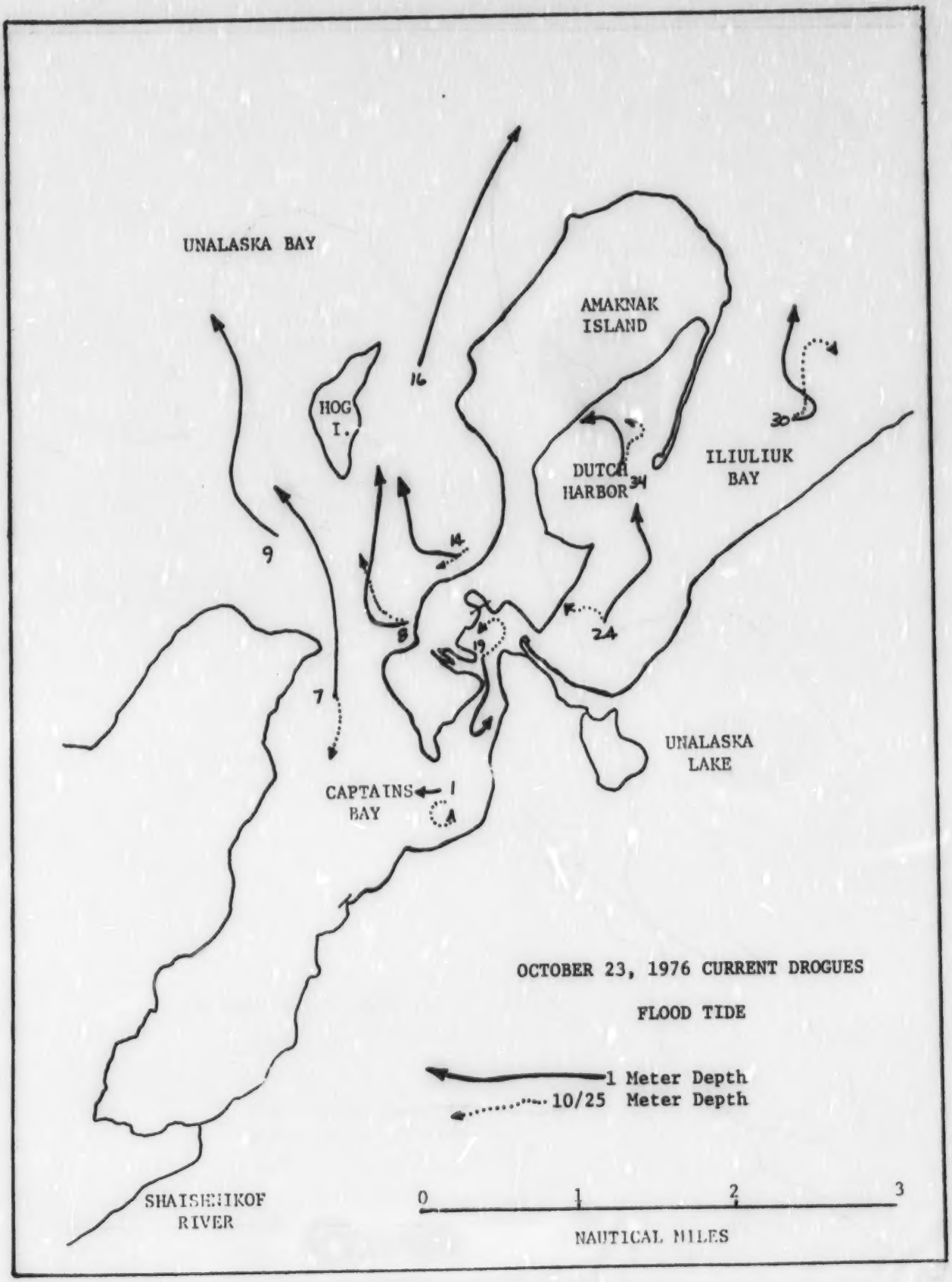

UNALASKA BAY
AMAKNAK ISLAND
HOG I.
DUTCH HARBOR
ILIULIUK BAY
UNALASKA LAKE
CAPTAINS BAY
SHAISHNIKOF RIVER
16
9
7
14
8
19
24
34
30
4
1
4
OCTOBER 23, 1976 CURRENT DROGUES
FLOOD TIDE
1 Meter Depth
10/25 Meter Depth
0
1
2
3
NAUTICAL MILES



FIGURE 6

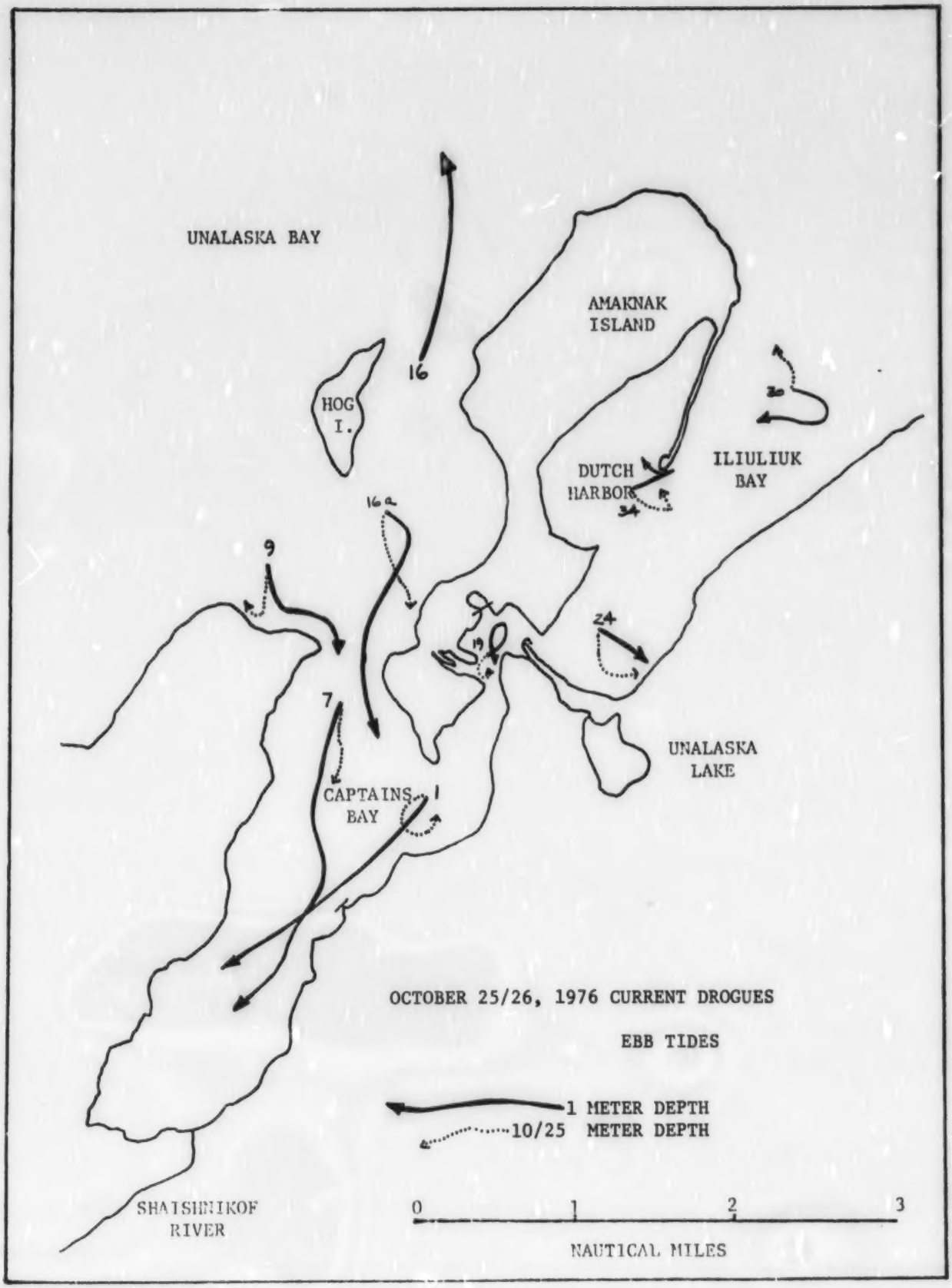

UNALASKA BAY
AMAKNAK ISLAND
HOG I.
16
DUTCH HARBOR
ILIULIUK BAY
16a
9
24
7
UNALASKA LAKE
CAPTAINS BAY
1
OCTOBER 25/26, 1976 CURRENT DROGUES
EBB TIDES
1 METER DEPTH
10/25 METER DEPTH
SHAISHNIKOF RIVER
0
1
2
3
NAUTICAL MILES



FIGURE 7

ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF ENFORCEMENT

# WASTE DISPOSAL PRACTICES OF CRAB PROCESSORS AT UNALASKA AND AMAKNAK ISLANDS, ALASKA

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
DENVER, COLORADO
AND
REGION X, SEATTLE, WASHINGTON
January 1977



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# WASTE DISPOSAL PRACTICES OF CRAB PROCESSORS AT UNALASKA AND AMAKNAK ISLANDS, ALASKA

In compliance with the National Pollution Discharge Elimination System (NPDES), provisions of the Federal Water Pollution Control Act, as amended, (33 U.S.C. + 1251 et. seg.; the Act) the Environmental Protection Agency, Region X authorized, in April 1975, the seafood processing facilities in the vicinity of Unalaska and Amaknak Islands to discharge seafood wastes into the adjacent receiving waters.

The seafood processing operations in the vicinity of Unalaska and Amaknak Islands are classified under the NPDES permit system as a "remote" area. The waste treatment requirement for this classification is to grind and discharge either directly into adjacent waters or by cross-island piping into less active areas.

It has been observed through recent investigations by the EPA that water quality problems associated with seafood processing are a direct function of receiving water conditions.* In areas with high tidal ranges and strong currents, waste materials can be rapidly dispersed. In more quiescent waters, accumulations of waste materials often result in sludge banks, shell piles, dissolved oxygen depressions, and associated aesthetic problems. The waters separating Unalaska and Amaknak Islands can be classified as comparatively quiescent; tidal range is 1.13 m and the tidal current in Dutch Harbor is inappreciable. In Iliuliuk Harbor the current velocity does not exceed 1 knot.** Therefore, it was anticipated that solid wastes (sludge and shell) would, in all probability, accumulate in the receiving waters adjacent to the seafood processors in these harbors.

A study to determine the extent of water quality problems and to obtain information supporting effluent limitations in the NPDES permits for the seafood processing operations at Unalaska and Amaknak Islands, Alaska, was conducted by Region X and National Enforcement Investigations Center (NEIC) personnel from October 20-27, 1976.

The objective of the study was to evaluate permit conditions prohibiting more than 7.6 cm (3 inches) accumulation of seafood wastes at a 30 meter (98 ft) radius of each crab processing plant outfall.

Observations of bottom conditions were made by SCUBA divers at all crab processing plant outfalls. At each location a team of divers examined the dispersion patterns of crab waste by conducting a general underwater reconnaissance of the bottom in the vicinity of the discharge.

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* Evaluation of Waste Disposal Practices of Alaska Seafood Processor, EPA, NEIC-D - Region X. December 1974.

** US Coast Pilot #9, Pacific and Arctic Coasts, Seventh (1964) Edition, US Department of Commerce, Coast and Geodetic Survey.

Pertinent data collected relating to the discharge area concerned the location, depth, and direction of the discharge pipe as well as the general bottom topography and current features likely to disperse the ground crab waste.

Following this preliminary investigation, core samples of crab processing wastes were collected at points 30 meters from the discharge. Later these core samples were examined and photographed to verify the actual depth of waste deposits. (Figures

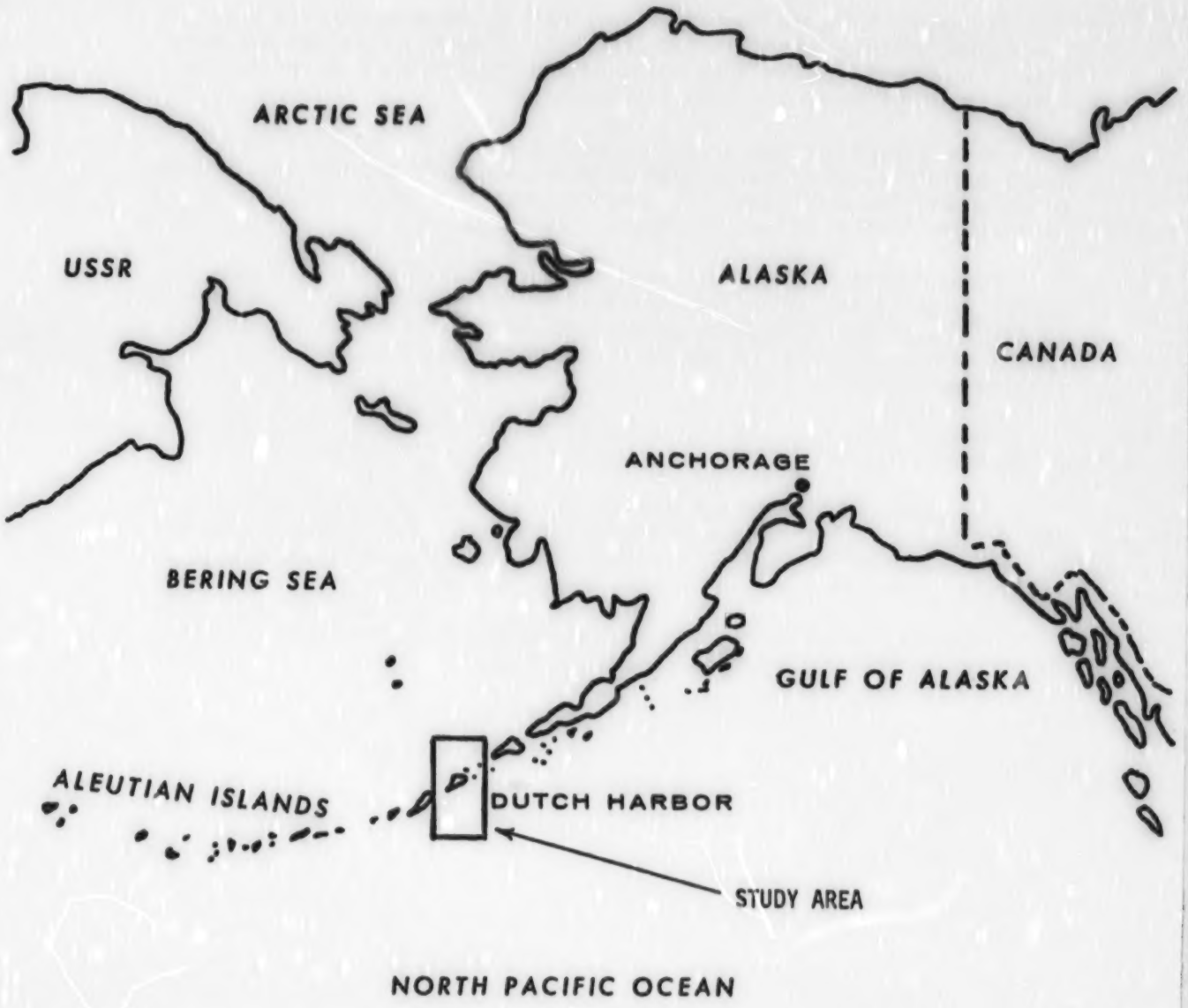
To supplement the observations made within the waste discharge area, additional diving examinations were conducted around, and in some cases under, the processing plant operation to ascertain possible alterations in the bottom conditions. (Figures

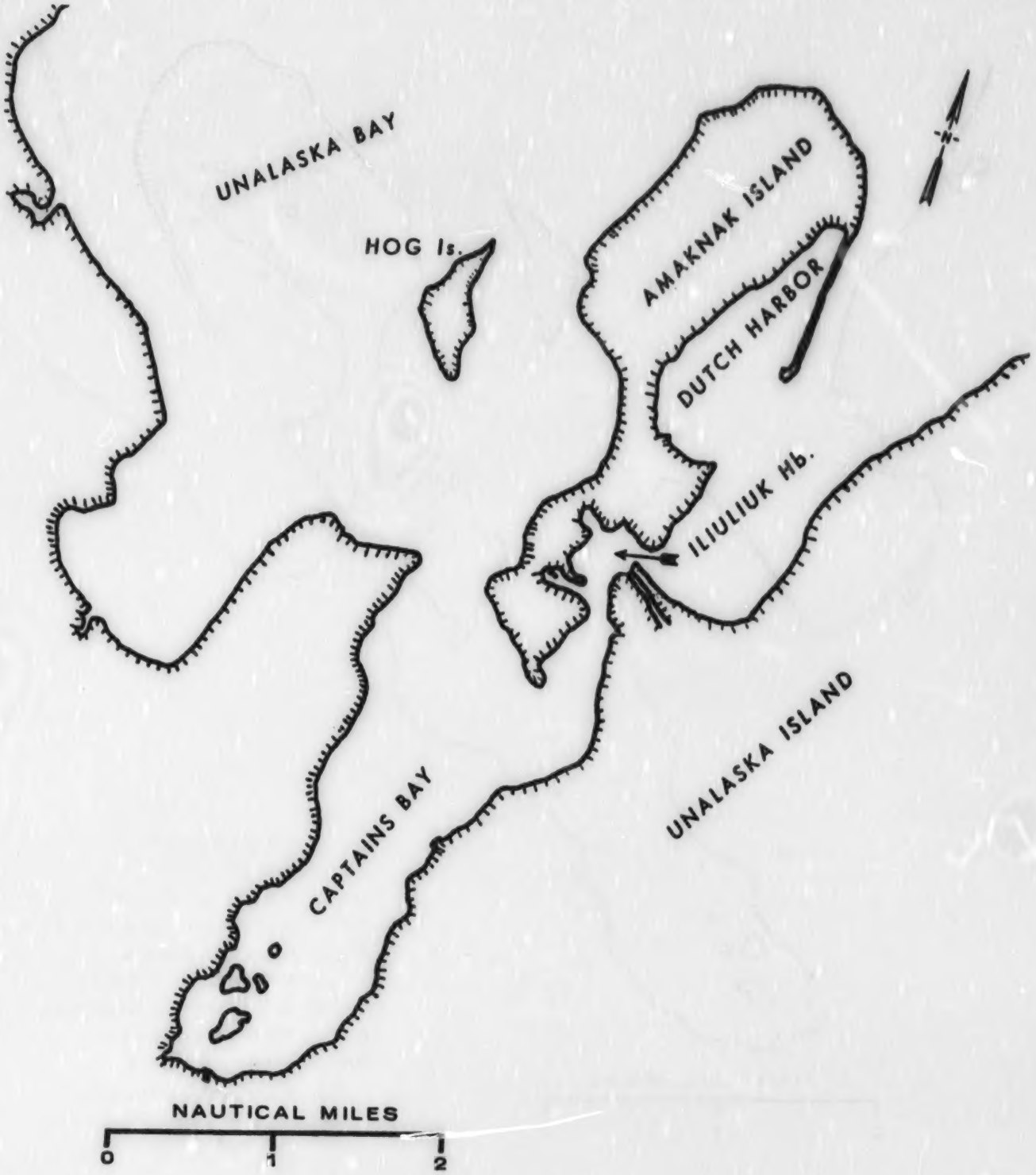
These investigations indicated the heavy build-up of crab waste deposits was caused by an apparent lack of bottom scouring or dispersion by tidal currents. Sludge deposits were observed in areas where crab wastes were discharged, ground or unground, in quiescent and relatively shallow water.

These conclusions are supported by visual observations of the dispersion patterns and their depth by biologically trained EPA SCUBA divers.

In summary, NPDES permit violations occurred at the discharges from the following seafood processing operations: M/V EASTPOINT, M/V UNISEA, M/V VICE ROY, and BARGE VITA I, M/V THERESA LEE, M/V ALASKA and M/V SEA PRODUCER. (Table

Presented below is a brief evaluation of conditions found at each of the crab processing plants.

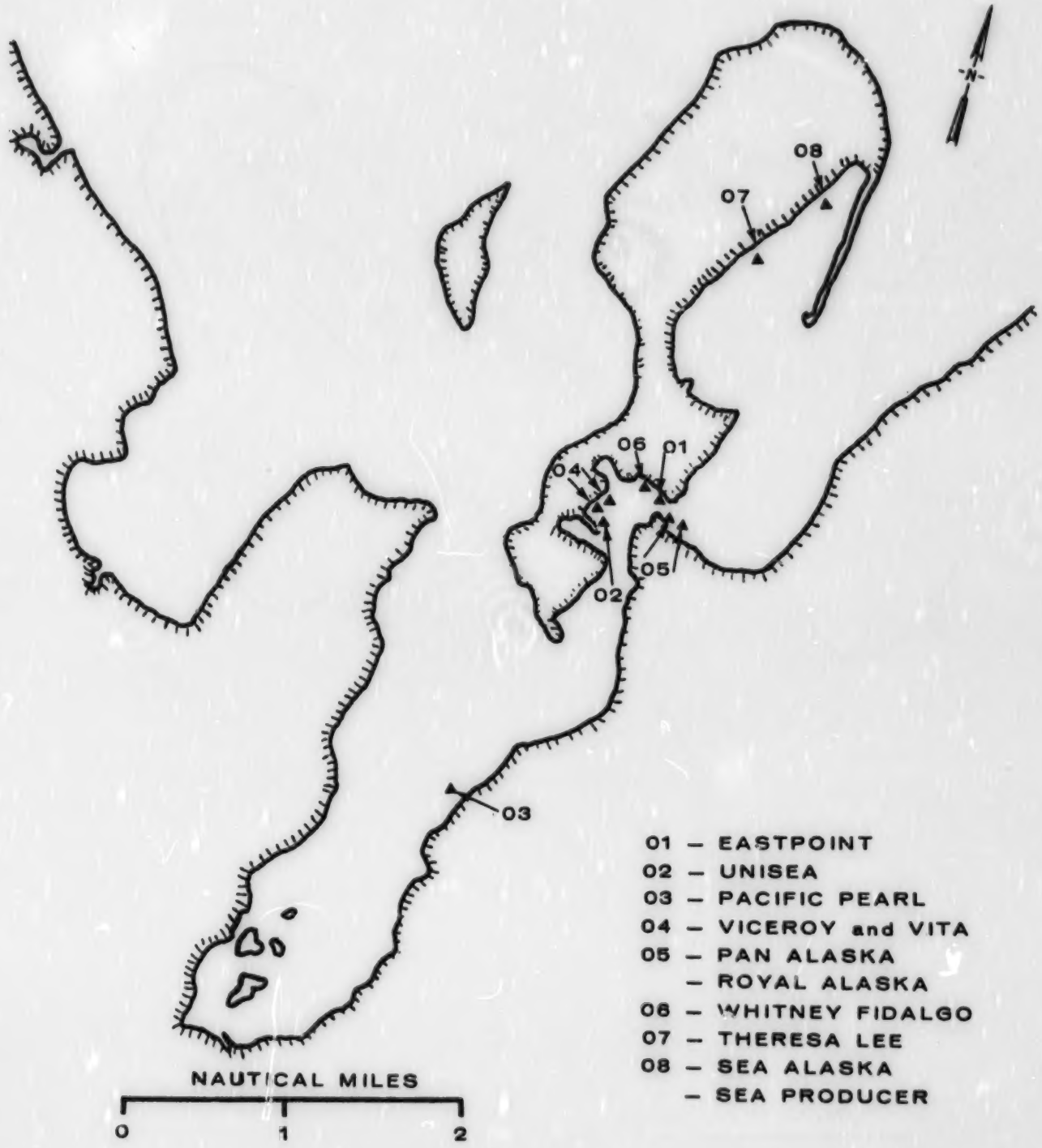

ARCTIC SEA
USSR
ALASKA
CANADA
ANCHORAGE
BERING SEA
GULF OF ALASKA
ALEUTIAN ISLANDS
DUTCH HARBOR
STUDY AREA
NORTH PACIFIC OCEAN




**Amaknak and Unalaska Islands**

**Alaska - Aleutian Islands**

**October 1976**

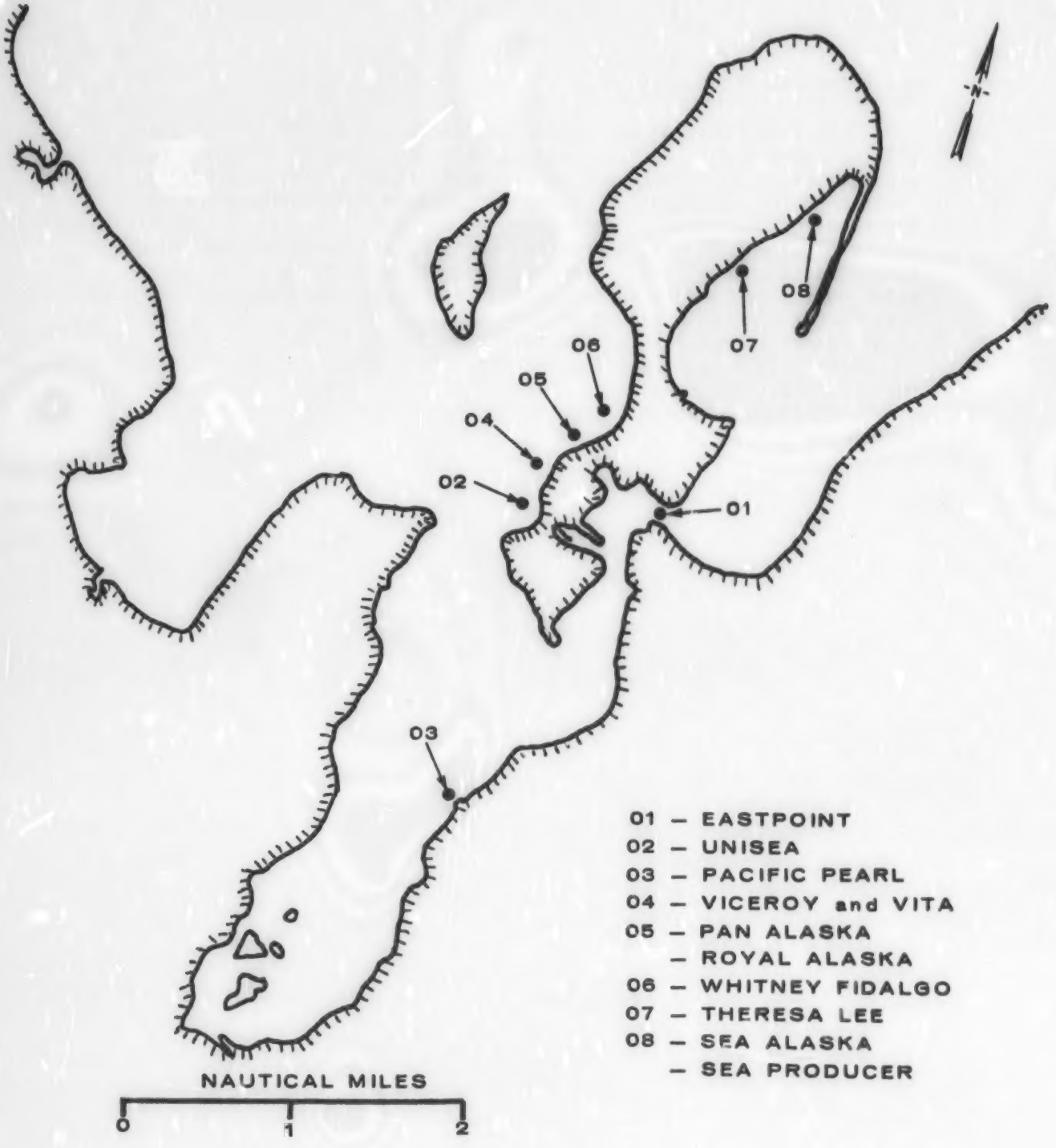



***Crab Processing Plants***

***Amaknak and Unalaska Islands***

***Alaska - Aleutian Islands***

***October 1976***




***Crab Plant Discharges***

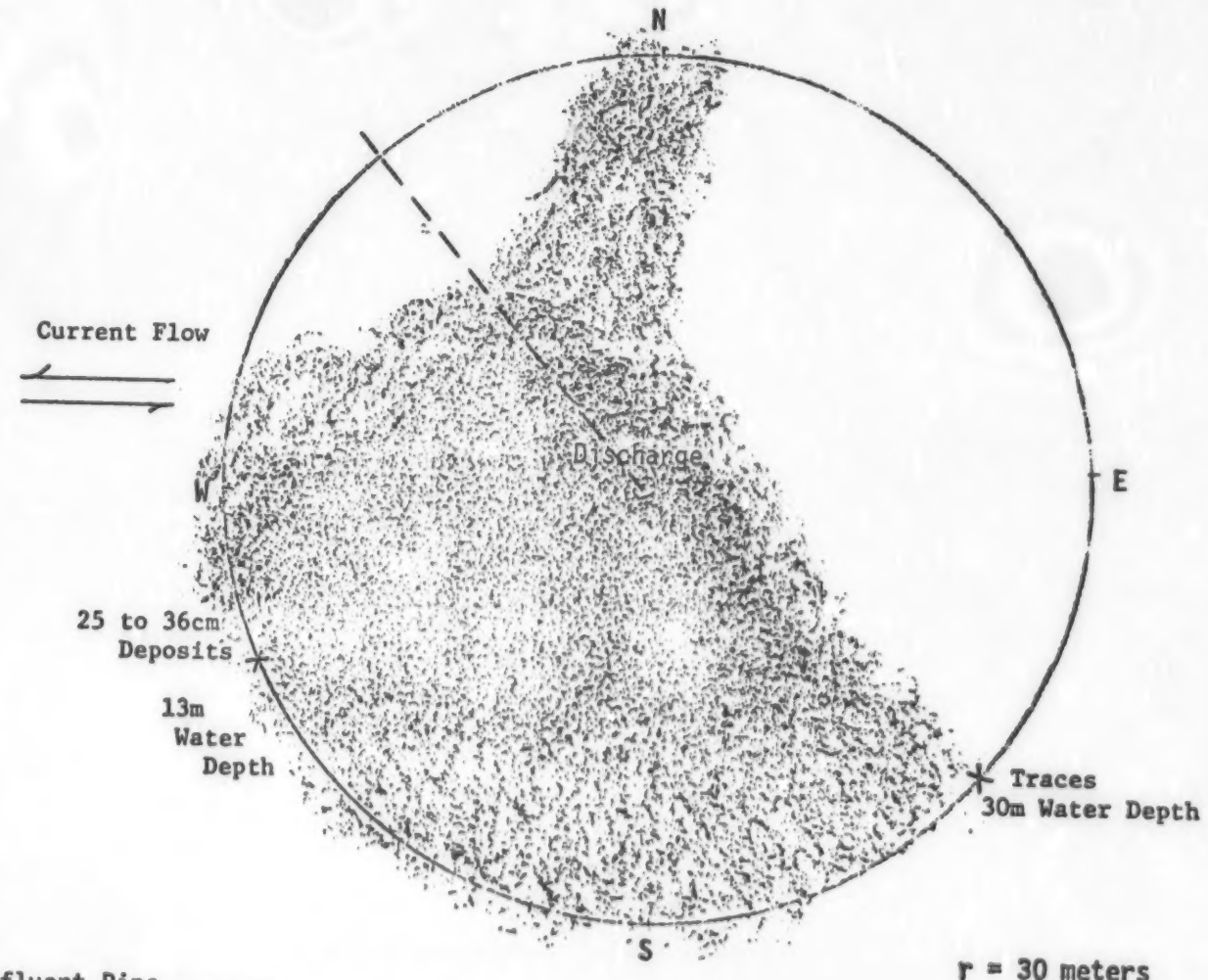
***Amaknak and Unalaska Islands***

***Alaska – Aleutian Islands***

***October 1976***

M/V EASTPOINT AK-002025-7

This is a floating crab processor docked on the northeast shore of Iliuliuk Harbor just inside the east entrance channel. The discharge of waste material is through a lightweight flexible rubber metal hose unattached to the bottom. Consequently, the final discharge point is dependent on the direction and force of the tidal current or the discharge pressure. About 30 meters from the point of discharge on the inside of the entrance channel waste deposits range from 25 to 36 cm in depth at water depths of 13 meters. In a south and southeast direction there are only traces of crab waste at a water depth of 30 meters. From the point of discharge to mid-channel the bottom falls off sharply to depths of 30 meters. In a southeast direction from the point of land the water remains relatively shallow to Iliuliuk Reef and beyond. Because of the narrow tidal range in this area the effect of tidal currents is negligible in the channel.

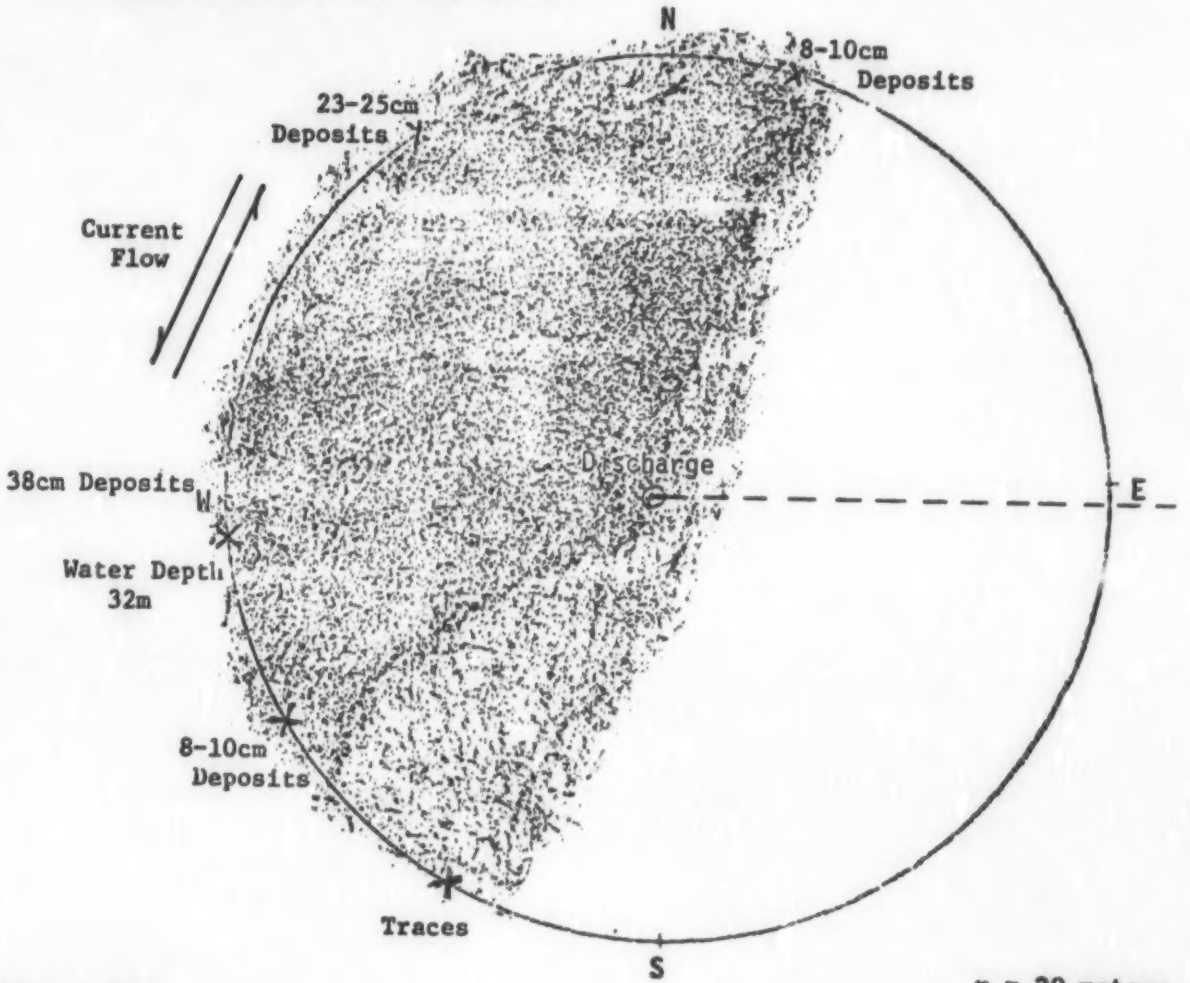


M/V UNISEA AK-002526-7

This is a floating crab processor docked on the north shore of Expedition Island in Iliuliuk Harbor. Ground crab waste from this operation is transported through a cross-island pipe and discharged at a depth of 17 meters in Unalaska Bay on the west side of Amaknak Island. The end of the pipe is secured to a tripod about 2 meters above the bottom.

At four points at a radius of 30 meters from the discharge pipe in a north to southwest zone, waste accumulations exceeded the limits prescribed by the NPDES permit. At the north point the accumulation was 8 to 10 cm, at the northwest point it was 23 to 25 cm, at the western point, at a water depth of 23 meters, it was 38 cm, and at the southwest point it was 8 to 10 cm. Directly west of the discharge pipe the crab wastes form a mound 13 meters long, 7 meters wide, and 4 meters high. Only traces of crab waste settled inshore of the discharge.

Current flow appeared to be along the shoreline in a north-south direction depending on the tidal phase. The extent of the accumulated waste and the definite westerly settling patten was a strong indication that the bottom currents were negligible.




Effluent Pipe -------

r = 30 meters
(98')

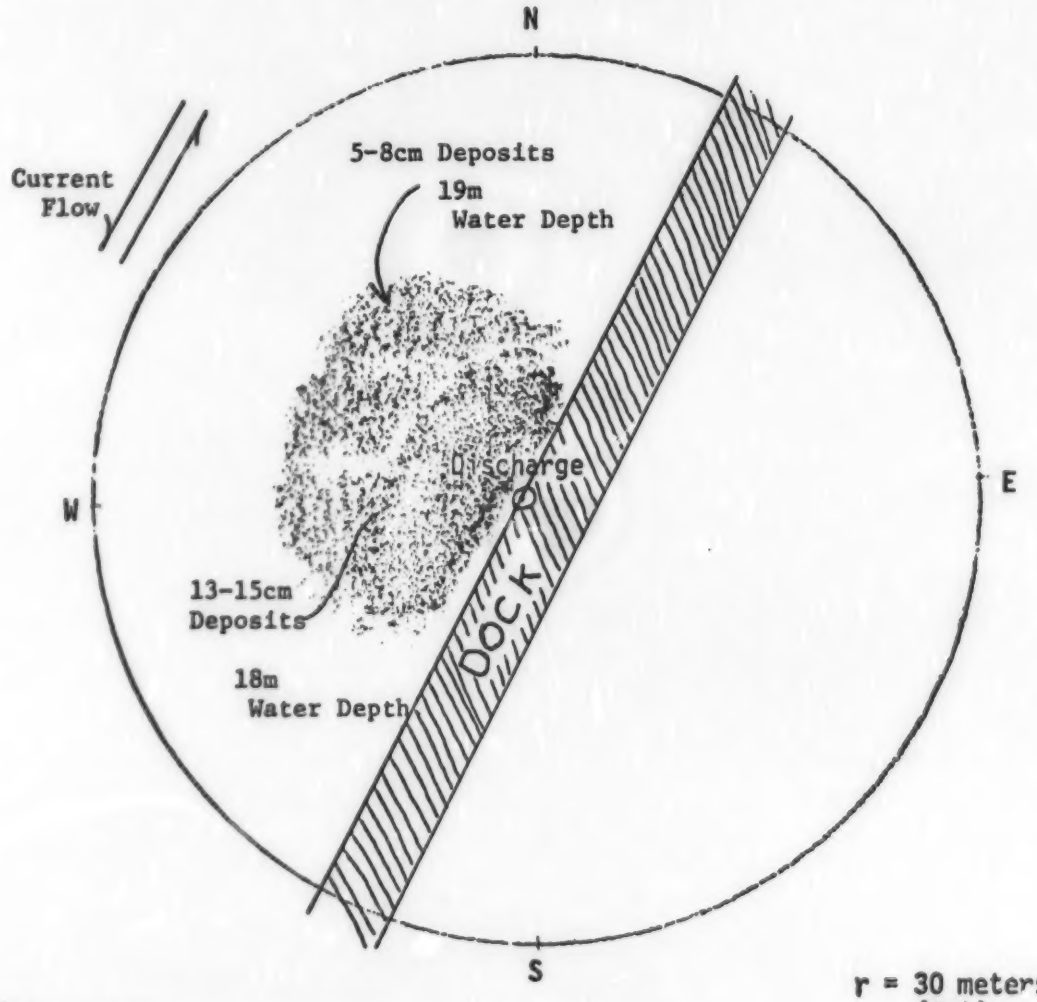
7.5 cm = 3 inches

PACIFIC PEARL AK-000125-2

This is a stationary crab processing operation located on the west side of Unalaska Island on the shore of Captain's Bay. The end of the discharge pipe is in a depth of 18 meters at the face of the loading dock.

Crab waste from this facility accumulated to a depth of 13 to 15 cm in the immediate vicinity of the discharge. Further offshore, in a northwest direction, the deposits were 5 to 8 cm at a water depth of 19 meters. No significant accumulations were found at the 30 meter radius of the discharge. Large crab sections were evident among the deposit which indicates that the grinder, at times, was working inefficiently.

Captain's Bay lies in a north-south direction at Unalaska Island and like the surrounding terrain is very sharp sided. The current flow, although not appreciable at the time of these observations, were apparently of sufficient magnitude to keep the deeper portions of the bottom adjacent to the outfall clear of heavy accumualtions of crab waste. Surface currents follow the contour of the shoreline and flow in a north-south direction.




Effluent Pipe -------

r = 30 meters (98')

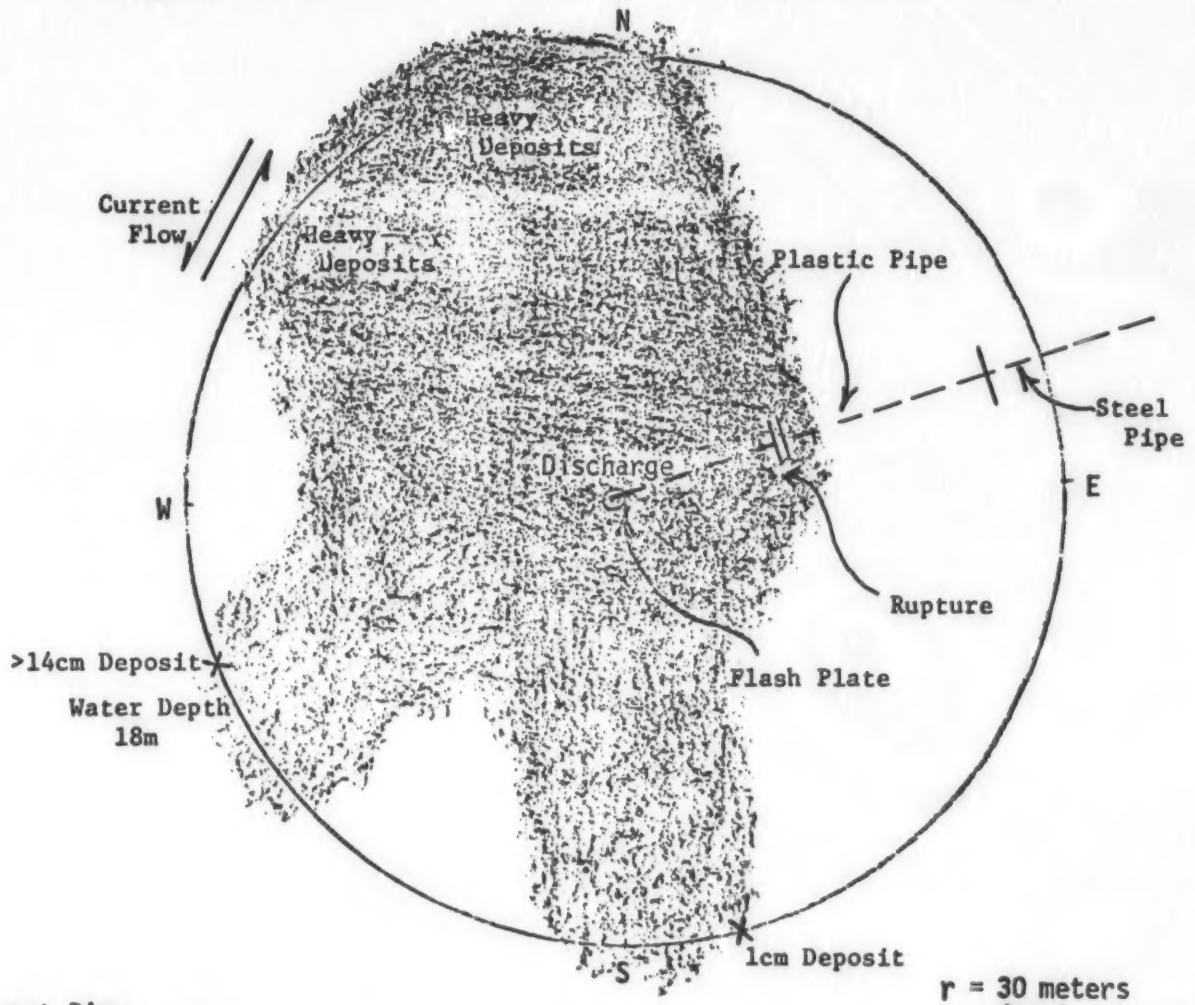
7.5 cm = 3 inches

M/V VICEROY AK-000068-0
BARGE VITA-I AK-000069-8

These operations are floating crab processors docked along the northwest shores of Iliuliuk Harbor. Combined crab waste from these two facilities is transported through a cross-island pipe and discharged into Unalaska Bay on the west side of Amaknak Island. The discharge pipe terminates about 2 meters above bottom. From shore the combined waste is carried in a steel pipe and then a plastic pipe which is ruptured about 23 meters from the end.

Observations at the 30 meter radius of the pipe rupture indicated heavy accumulations of crab waste in a north to southwest section. A sample taken at the southwest point, in a water depth of 18 meters, showed a deposit of waste more than 14 cm in depth. In a southeast direction the deposits fluctuated around 1 cm.

Bottom topography in this area can be classified as sloping gradually. Current flow appears to follow the shoreline in a north-south direction depending on the phase of the tide. The amount of accumulated waste and the southwest settling pattern was an indication that the bottom currents are negligible.




Effluent Pipe -------

r = 30 meters (98')

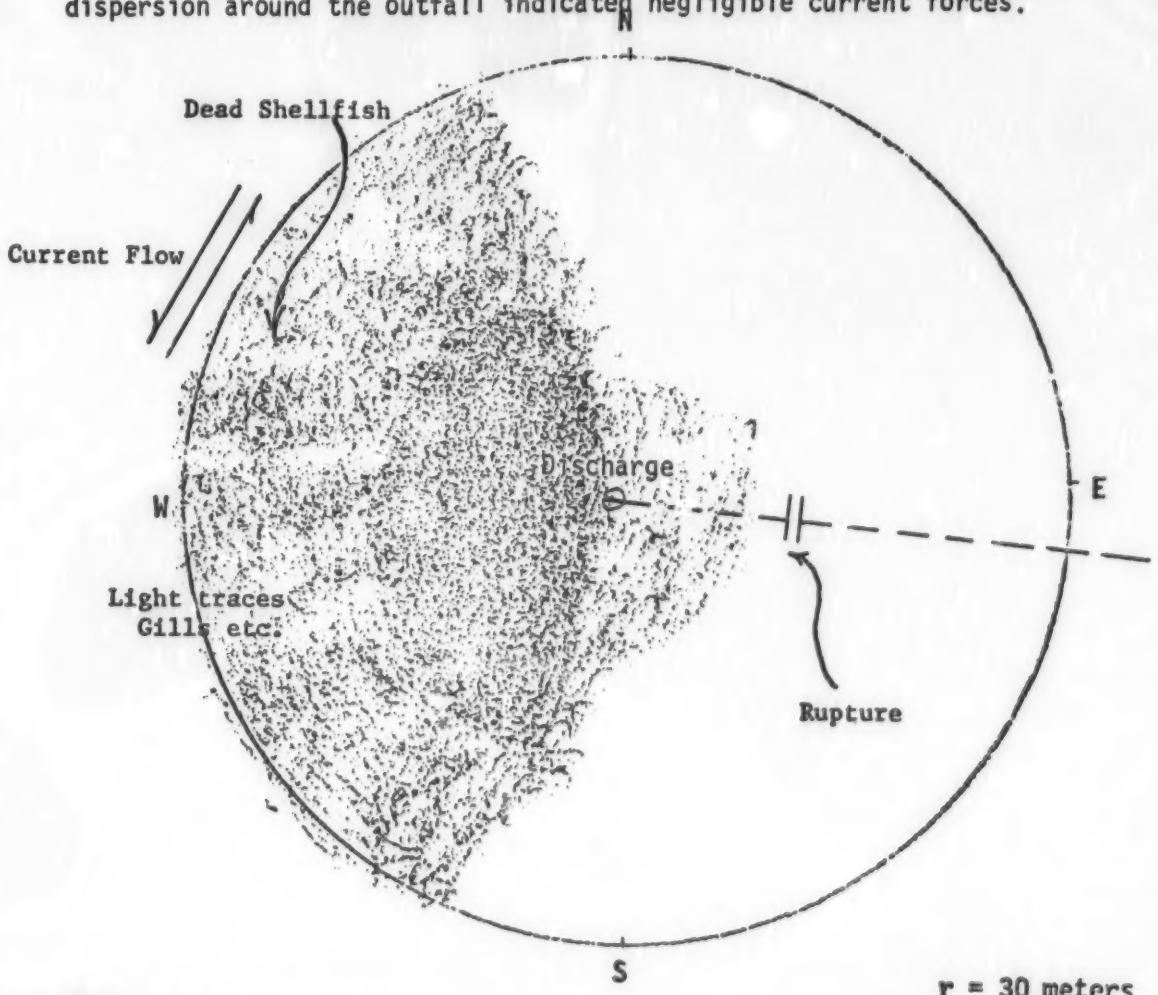
7.5 cm = 3 inches

PAN ALASKA AK-000027-2
M/V U.S. ROYAL ALASKAN AK-002493-7

The Pan Alaska operation is a stationary facility located at the end of a peninsula on Unalaska Island in the southeast sector of Iliuliuk Harbor. Royal Alaskan is a floating crab processor located in the same general area and docked at a pier running parallel to the entrance channel to Iliuliuk Harbor. Combined crab waste from these two processors is transported through a cross-island pipe and discharged at a depth of 12 meters into Unalaska Bay on the west side of Amaknak Island. An underwater rupture appears in the pipe about 15 meters before it reaches the point of discharge.

Heavier deposits from this discharge were within the 30 meter radius of the discharge point. Only light traces of the more finely ground waste were evident in the outer reaches. However, at this outer edge there were noticeable quantities of dead and dying shellfish under this light layer of crab waste. (Figure

Bottom topography in this area is of a steady sloping type. Current flow appears to be along the shoreline in a north-south direction depending on the phase of the tide. The volume of accumulated waste and its general dispersion around the outfall indicated negligible current forces.




Effluent Pipe -------

r = 30 meters
(98')

7.5 cm = 3 inches

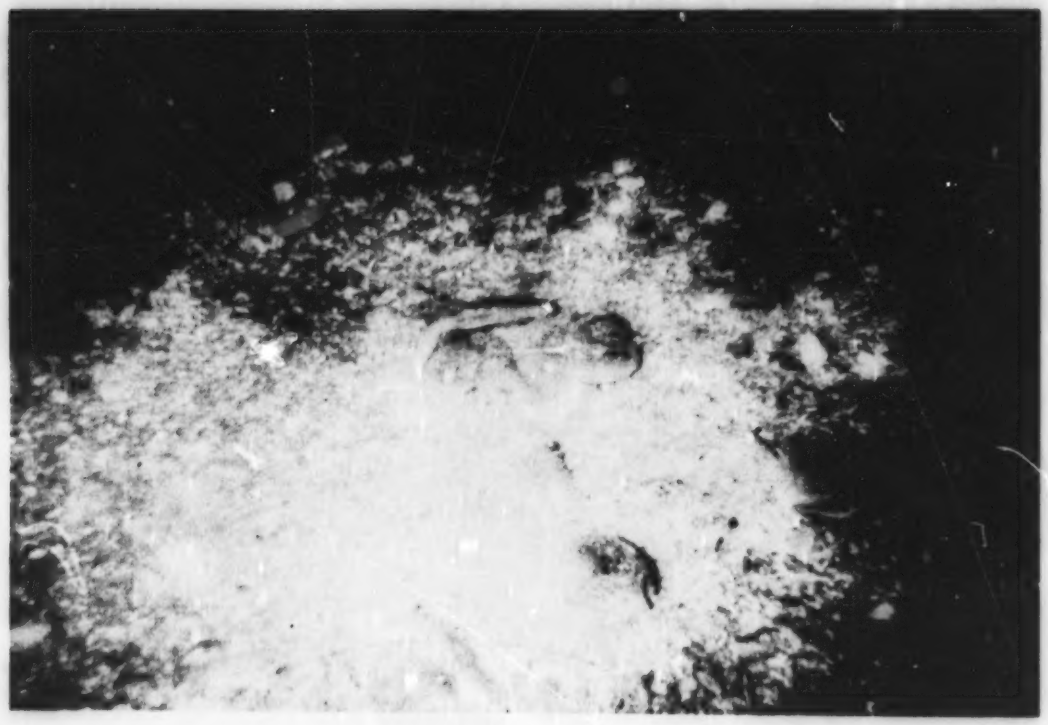


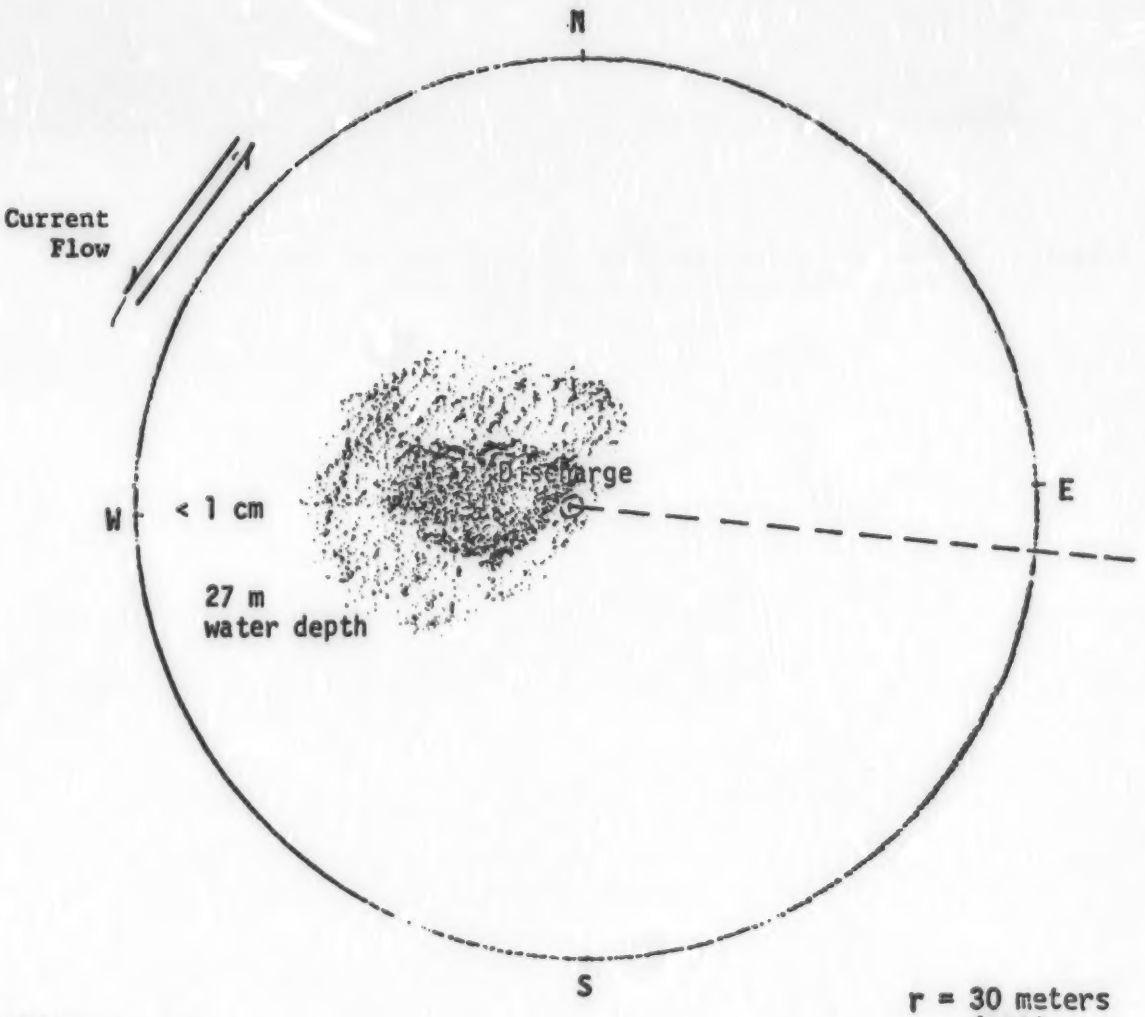
Figure Dead and dying shellfish in the discharge area of the PAN ALASKA and M/V O. S. ROYAL ALASKAN.

WHITNEY FIDALGO AK-002618-2

This is a floating crab processing facility docked on the north shore of Iliuliuk Harbor. The resulting crab waste from the operation is transported through a cross-island pipe and discharged at a depth of 13 meters into Unalaska Bay on the west side of Amaknak Island.

Observations made by SCUBA divers along the bottom in the general area of crab waste settling showed a relatively clean situation. This was apparently a result of the infrequent operation of this processing operation.

Bottom topography in this area is a steady sloping type. Current flow appeared to be in a north-south direction and the force is negligible. (Figure



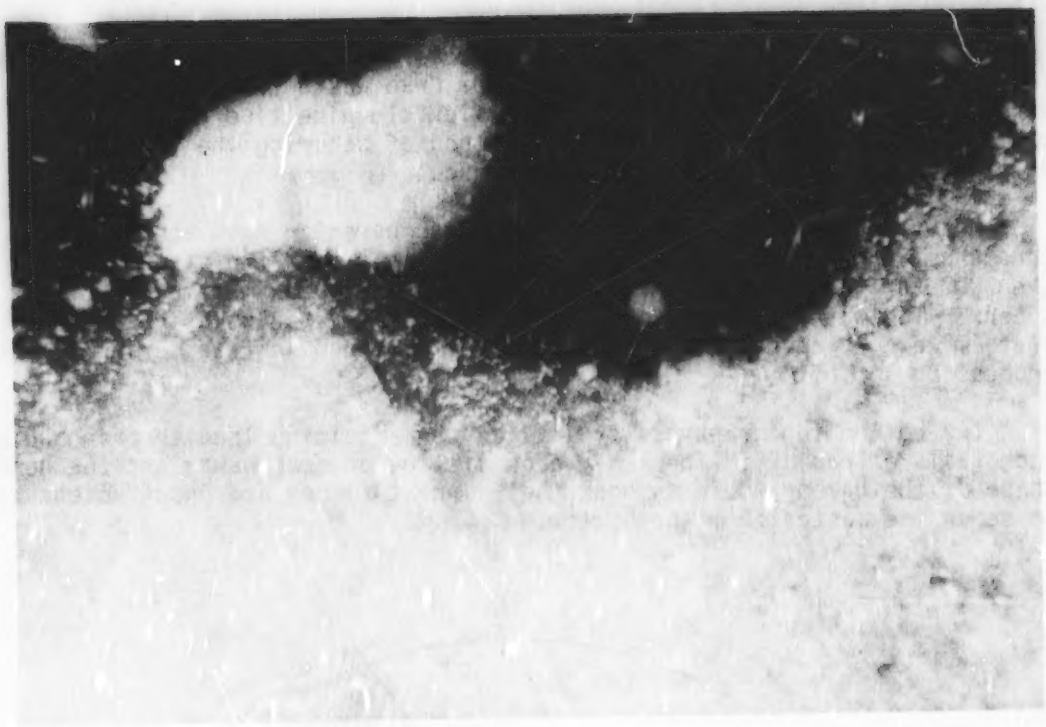


Figure A sea anemone being buried by ground crab waste.

M/V THERESA LEE AK-000062-1

This is a floating crab processor docked at a pier along the northwest shore of Dutch Harbor on Amaknak Island. Crab waste from this facility is discharged into Dutch Harbor through a flexible pipe tied to the anchor cable at a depth of 12 meters. This method of securing the pipe causes a whiplash effect during periods of discharge. (Figure

Heavy deposits of crab waste from this operation have accumulated throughout the general area. At a point southeast of the discharge, at the 30 meter radius, deposited waste reached an approximate depth of 1.2 meters. The water depth at this point is 30 meters. Extensive patches of foam were evident in the immediate area of the discharge during time of processing. (Figure

The bottom topography is typical of the adjoining land terrain and as such falls of rapidly. The heavy accumulation of crab waste and the general shape of the harbor would suggest that current forces are insufficient to scour the wastes from the bottom.

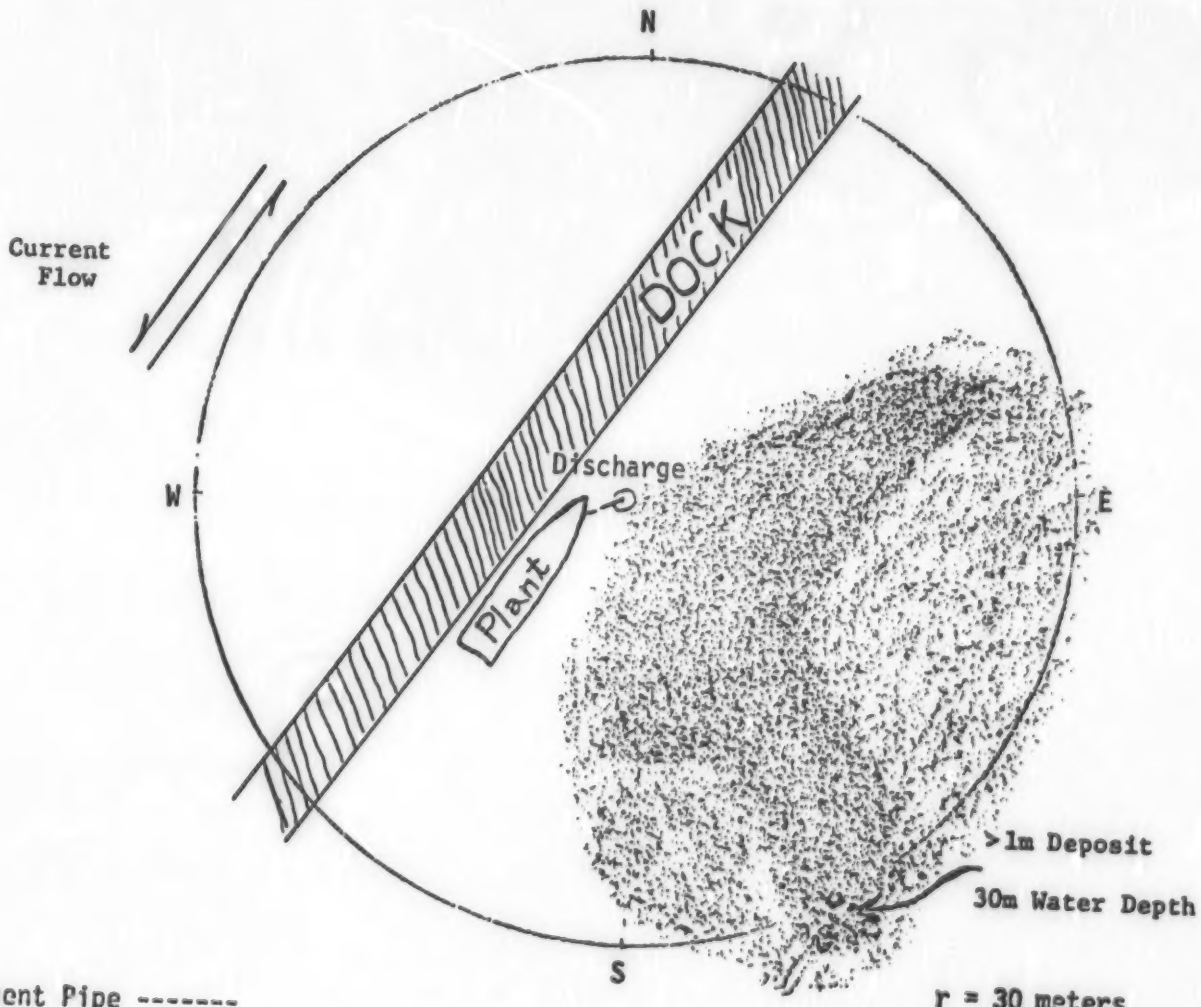


Figure Discharge pipe of the M/V THERESA LEE secured to the anchor chain.

Figure Core sample taken at a point 30 meters from the discharge of the M/V THERESA LEE. Backboard is marked in inches.

M/V SEA ALASKA AK-002257-8
M/V SEA PRODUCER AK-002250-1

These floating crab processors are docked at a pier in the northern sector of Dutch Harbor on the eastern shore of Amaknak Island. The combined crab waste from these two facilities is discharged into Dutch Harbor through a single pipe at a depth of 23 meters.

Extremely heavy deposits of crab waste from these processors surround this outfall. Divers observations indicated a conical mound of waste approximately 8 meters high and 12 meters wide at the base, tapering off to about 1 meter in depth at an eastern point of the 30 meter radius of the discharge. (Figure

These processors are located in a dead-end pocket of Dutch Harbor where there is apparently no current of any magnitude available to disperse the crab waste. Consequently an extreme build-up is expected to continue.

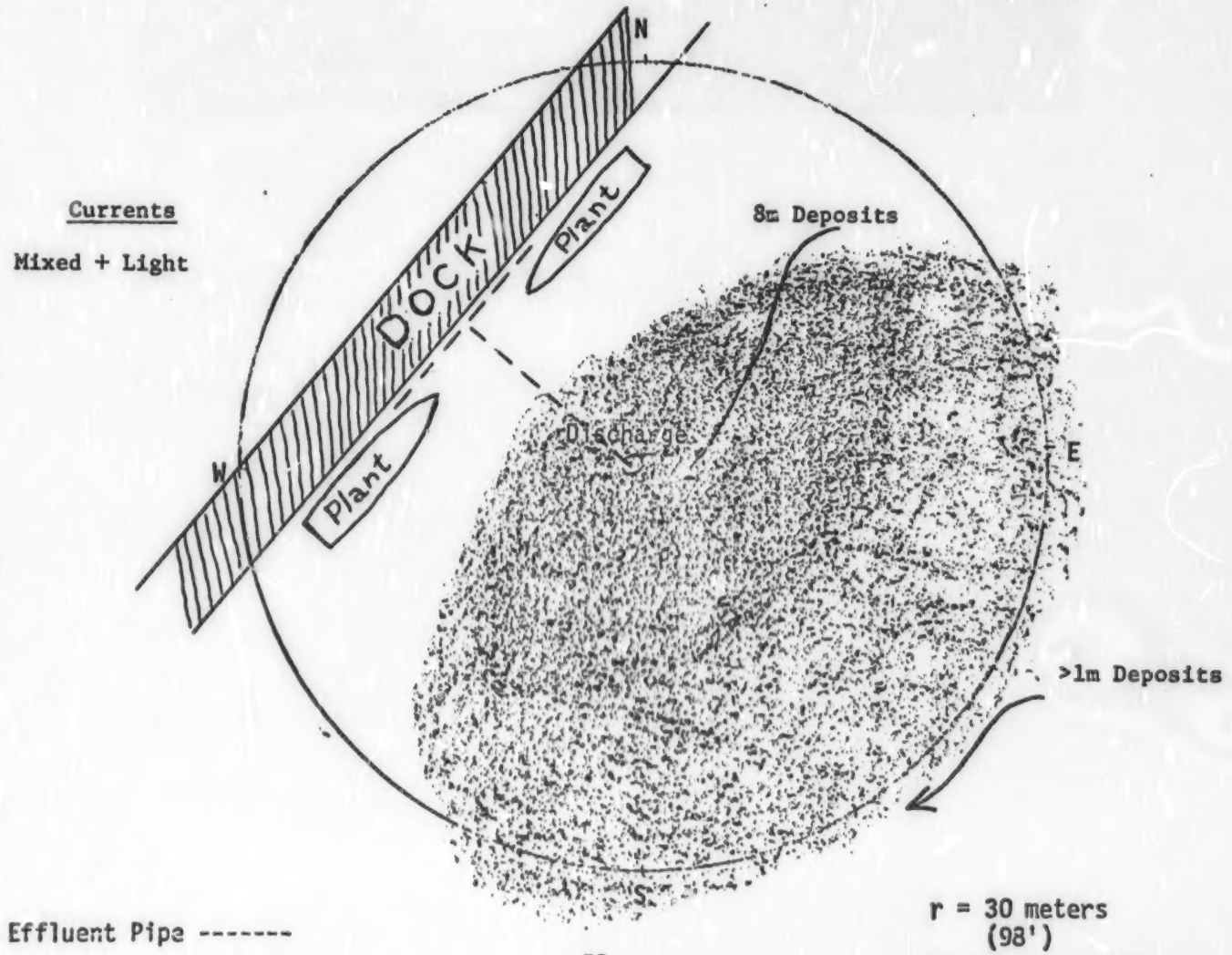


Figure Core sample taken at a point 30 meters from the M/V SEA ALASKA and M/V SEA PRODUCER discharge. Backboard is marked in inches.

Table

CRAB WASTE DISPOSAL METHODS

| Processor | NPDES Permit | Type | Location | Disposal Method | Remarks | NPDES Compliance |
|---|---|---|---|---|---|---|
| M/V EASTPOINT | AK-002025-7 | Floater | Iliuliuk Hb. Amaknak Is. | Ground waste discharged into Iliuliuk Hb. through flexible hose. | Pipe not secured to bottom. Discharge point dependent on tidal phase. | No |
| M/V UNISEA | AK-002526-7 | Floater | Iliuliuk Hb. Amaknak Is. | Ground waste discharged cross-island into Unalaska Bay. | Deposits mound 4 meters high, 13 meters long and 7 meters wide in front of pipe. | No |
| PACIFIC PEARL | AK-000125-2 | Stationary | Captain's Bay Unalaska Is. | Ground and unground waste discharged into Captain's Bay. | Indications of inefficient grinder. | Yes |
| M/V VICEROY<br>Barge VITA I | AK-000068-0<br>AK-000069-8 | Floaters | Iliuliuk Hb. Amaknak Is. | Combined ground waste discharged into Unalaska Bay. | Ruptured plastic pipe before discharge point. Heavy deposits north and west. | No |
| PAN ALASKA<br>M/V ROYAL ALASKAN | AK-000027-2<br>AK-002493-7 | Stationary<br>Floater | Iliuliuk Hb. Amaknak Is. | Combined ground waste discharged into Unalaska Bay. | Ruptured pipe before discharge point. Dead and dying shellfish around perimeter of deposits. | Yes |
| WHITNEY FIDALGO | AK-002618-2 | Floater | Iliuliuk Hb. Amaknak Is. | Ground waste discharged into Unalaska Bay. | This processor not in operation. Bottom fairly clean. | Yes |
| M/V THERESA LEE | AK-000062-1 | Floater | Dutch Hb. Amaknak Is. | Ground waste discharged into Dutch Hb. Pipe secured to anchor chain at 12 meters. | Heavy deposits of waste in southeast direction of discharge. | No |
| M/V SEA ALASKA<br>M/V SEA PRODUCER | AK-002257-8<br>AK-002250-1 | Floaters | Dutch Hb. Amaknak Is. | Combined ground waste discharged into Dutch Hb. | Heavy deposits of waste around discharge point and at 30 meter radius. | No |